Screening Site Inspection Report, Part 1

for

Mobile Waste Controls
TXD 988051652
Houston, Texas

Prepared in cooperation with

Texas Water Commission
and
U.S. Environmental Protection Agency

December 1992

ES ENGINEERING-SCIENCE

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MOBILE WASTE CONTROLS

TXD 988051652

HOUSTON, TEXAS

INTRODUCTION

Engineering-Science, Inc. (ES) has been contracted by the Texas Water Commission (TWC) to conduct a screening site inspection (SSI) at the Mobile Waste Controls site (EPA identification number TXD 988051652). This site is located on approximately 25 acres at 10000 Minnesota Road in southeast Houston, Harris County, Texas.[ref. 1] Figure 1 is a site location map. This report was prepared to describe the site reconnaissance and sampling activities which are recommended to be performed at the site. Figure 2 is a site sketch.

This document is part 1 of a two-part report detailing SSI activities at the Mobile Waste Controls site. This report details site background information and field activities. Field activities, conducted October 12 through 15, 1992, included site reconnaissance, record searches, and sample collection (SSI site visit). The site visit was conducted by Brian Vanderglas, Dan Kelmar, and Kelly Krenz of ES. Photographs taken during the site visit are in appendix A. Figure 3 depicts photograph locations and directions. Analytical results from the samples collected at the site during the SSI and conclusions based on those results are presented in part 2 of this report.

The information gathered for this SSI was obtained from several sources: TWC, Texas Department of Health (TDH), and City of Houston files, as well as numerous agencies and publications. A complete list is in the reference section.

SITE OBJECTIVES WITH RESPECT TO THE PREREMEDIAL PROCESS

The preremedial stage of the Superfund process involves an expanded preliminary assessment (PA) and a site inspection (SI) stage consisting of an SSI and, if necessary, a listing site inspection (LSI). The activities described in this report fulfill the requirements for a focused SSI.

The goal of this SSI was to build on data gathered during the PA by assembling additional background data and collecting environmental samples which further

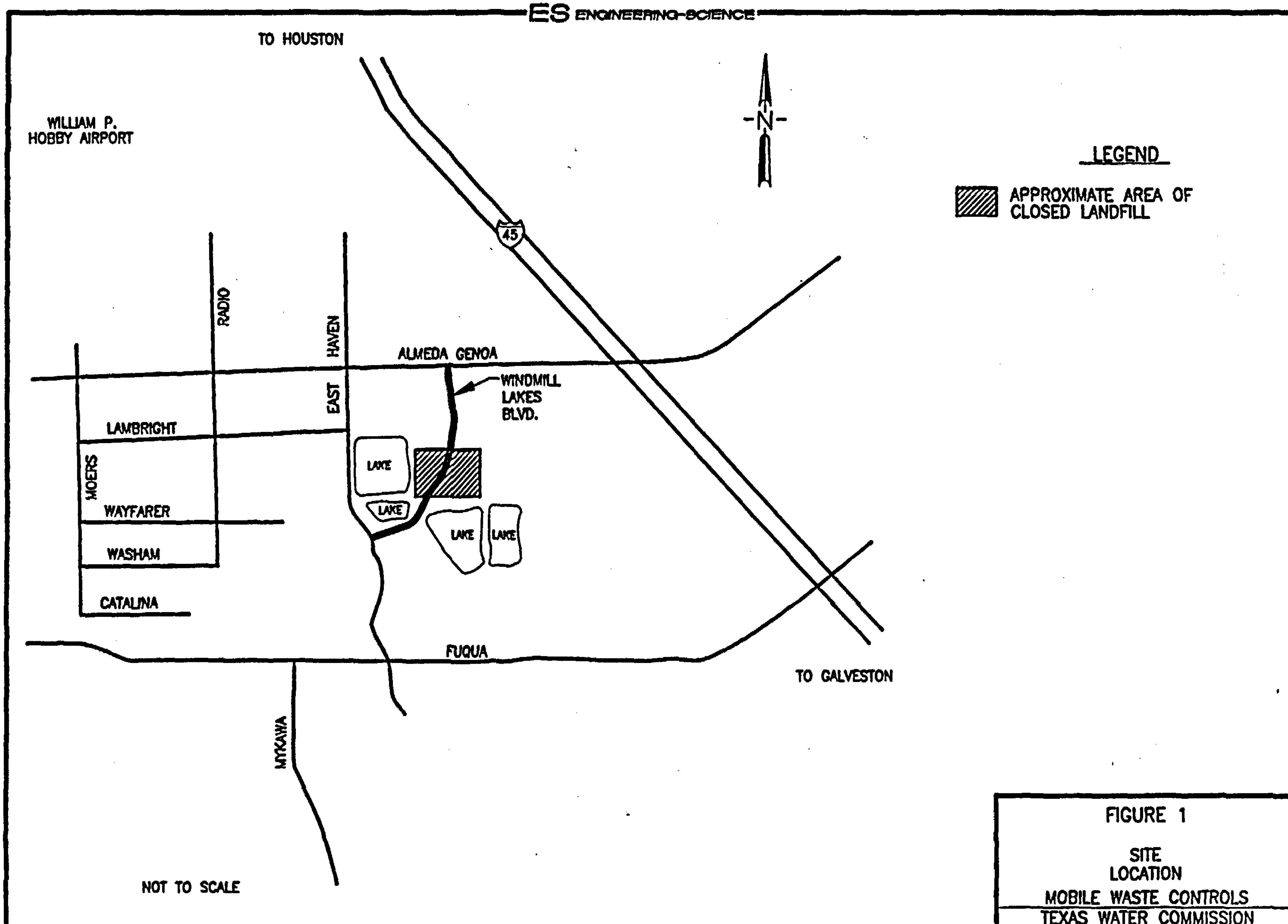

FIGURE 1

SITE LOCATION

MOBILE WASTE CONTROLS

TEXAS WATER COMMISSION

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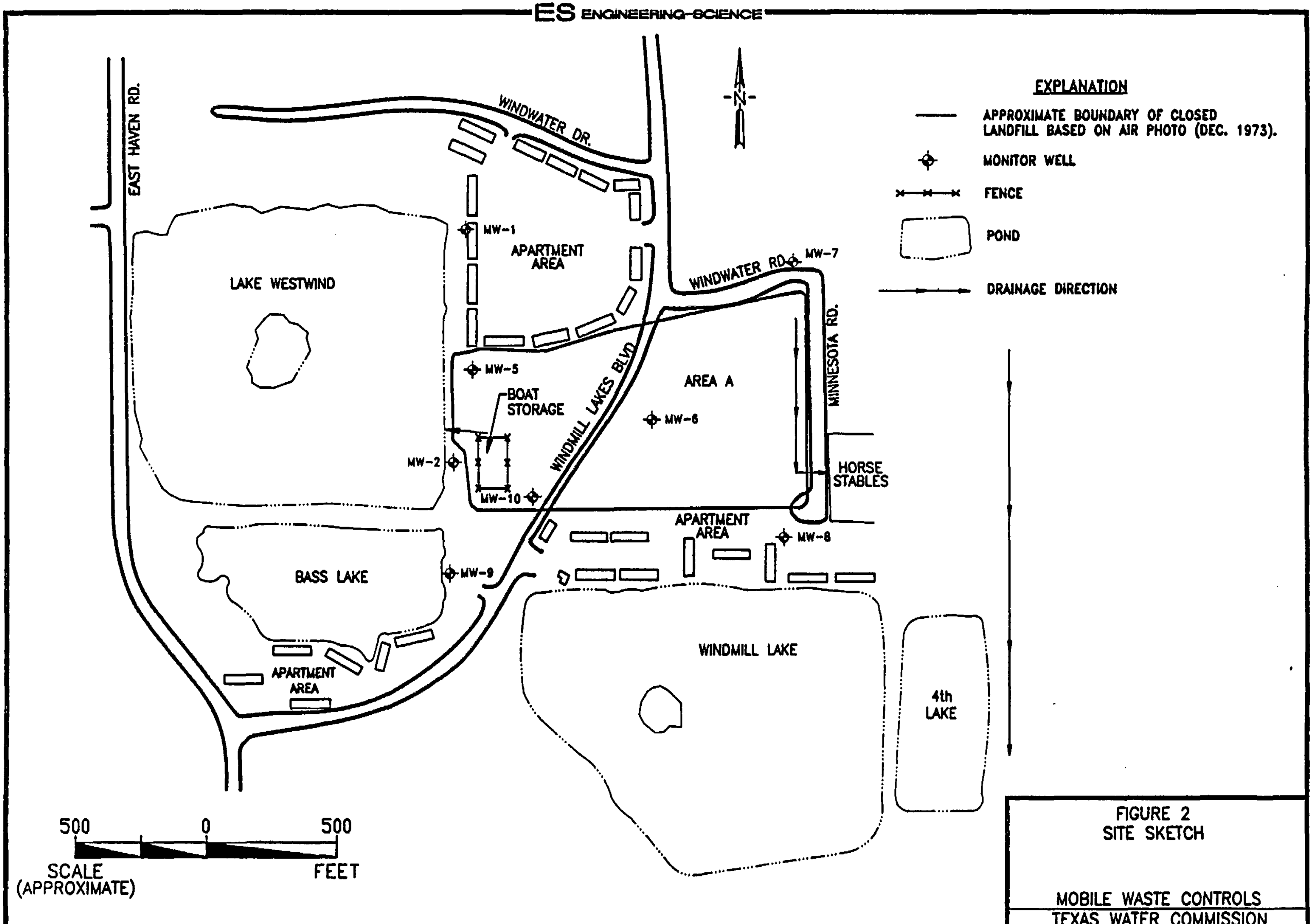

FIGURE 2
SITE SKETCH

MOBILE WASTE CONTROLS
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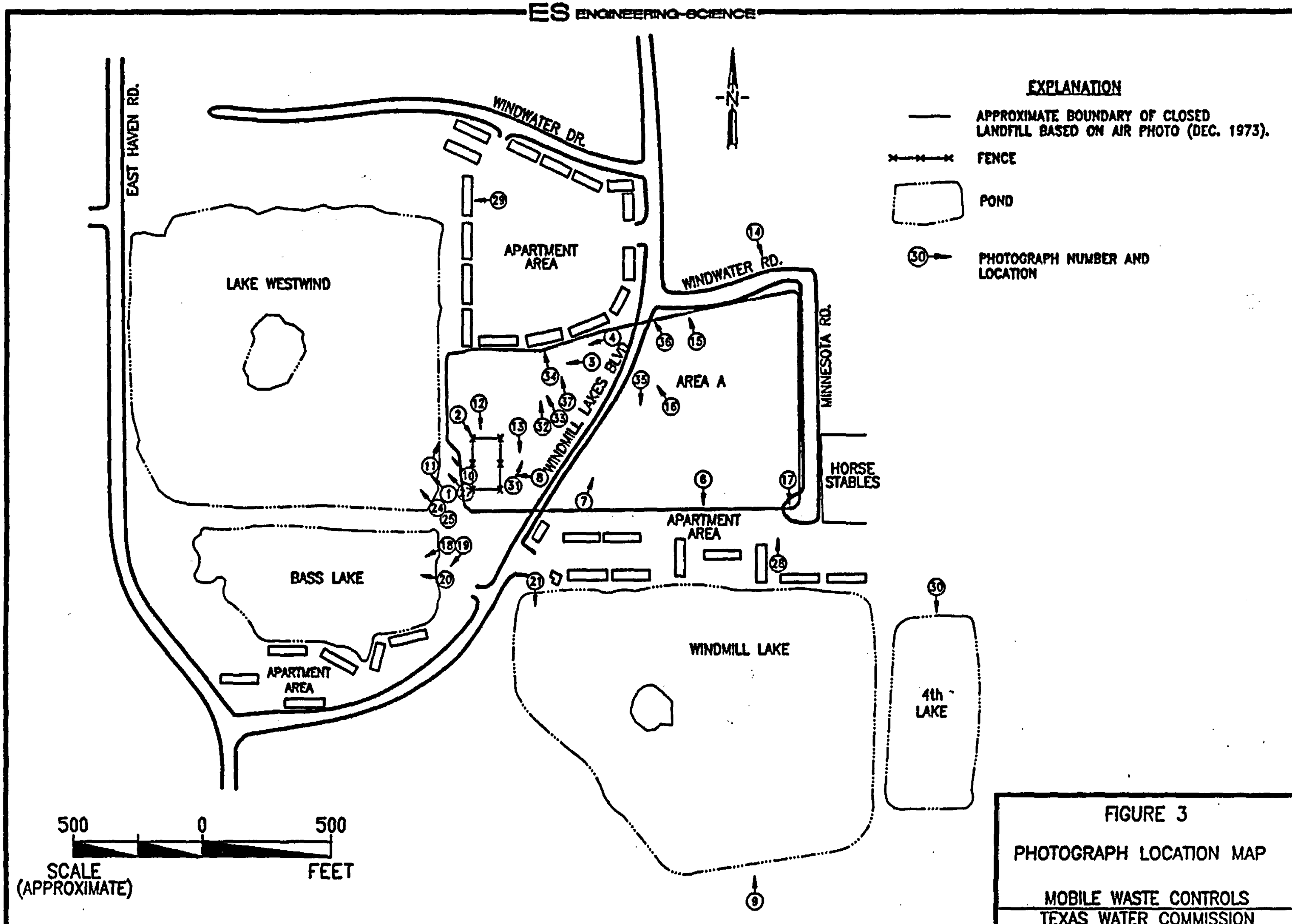

FIGURE 3

PHOTOGRAPH LOCATION MAP

MOBILE WASTE CONTROLS

TEXAS WATER COMMISSION

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characterize conditions at the site. Sampling conducted during the SSI was designed to identify the types of contaminants present, if any; to assess whether a release of hazardous substances has occurred; to look for evidence of actual human and environmental exposure to contaminants; and to determine whether a site will move forward to an LSI or be designated as "no further remedial action planned."

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SITE BACKGROUND AND DESCRIPTION

The inactive Mobile Waste Controls site is located at 10000 Minnesota Road in Houston, Harris County, Texas, half a mile west of the intersection of Almeda-Genoa Road and IH 45.(ref. 1) The geographic coordinates of the site are approximately 29°37′19" north and 95°13′59" west.(ref. 1) As depicted in Figure 2, the site (area A) is a maintained grass field transected by Windmill Lakes Boulevard, with a fenced boat storage area along the western edge of the site.(ref. 2) The site is bordered on the north and south by apartment complexes (Windmill Landing Apartments); to the west by Lake Westwind, which serves as a local recreational area; and to the east by a vacant lot and horse stable.(ref. 3)

According to Harris County tax records, the FDIC owns approximately 121.9 acres surrounding and including the site.(ref. 4) The property is managed by Ameresco Management, Inc.(ref. 4) During the late 1960s, the area was an active sand quarry.(ref. 1) Five deep pits were excavated at the site: two large (1,000-foot-diameter) and three small (300-foot-diameter). Precipitation, surface water runoff, and groundwater accumulation caused both large pits and two of the small pits to become four small lakes.(ref. 1) The fifth pit was used as a landfill and is the subject of this investigation.

From 1969 through 1981, the property was owned by Realty Reclamation, Inc. and operated as an industrial and commercial landfill by Wallace Waste Control Company, Metropolitan Waste Conversion, National Disposal Contractors, and Mobile Waste Controls, Inc.(ref. 1)

By 1972, one of the small, unlined pits (Figure 2, area A) was two-thirds filled with industrial and commercial wastes.(ref. 1) City of Houston representatives documented receipt at the site of industrial chemicals and municipal and putrescible wastes, as well as several fires and odor problems.(ref. 1) An unknown quantity of industrial chemicals were disposed of in this pit for at least 5 years, ending in 1974.(ref. 1) In addition, wood, paper, plastics, rubber, metal, neoprene, Styrofoam, urethane, PVC pellets, plastic resins, asbestos, oil-contaminated filter cake, asphalt, and municipal garbage have been disposed of in the landfill.(ref. 1) The total volume and precise composition of the waste disposed of at the site is not known. A final clay cap was placed over the landfill.(ref. 1) No information was found indicating the type or time of cap construction.

In 1982, Levering & Reid created Windmill Lakes subdivision and constructed three apartment complexes bordering the lakes. As part of the construction, a landfill investigation including the installation of wells was conducted. The PA, conducted on December 19, 1991, specified air, groundwater, surface water, and soil exposure as pathways of concern.

The thickness of the final cover of the capped disposal area (area A, Figure 2) varies from less than 6 inches over the large, central portions of the area to over 6 feet in areas along the north side of the closed landfill.(ref. 1) Exposed waste materials were observed in numerous bare soil areas, apparently where the landfill cap is thin (appendix A, photos 3 through 8, 13, and 15).

Windmill Lakes Boulevard was constructed across the landfill site during construction of the Windmill Lakes subdivision.(ref. 1) The landfill cap was disturbed by surveying and construction, resulting in exposure of waste material, which was subsequently covered with additional soil.(ref. 1)

The landfill cover is kept saturated in low-lying areas along Windmill Lakes Boulevard by what appears to be an in-ground sprinkler system.(ref. 2) Standing water and marshlike vegetation were apparent in low areas adjacent to the boulevard (appendix A, photo 16). Surface water drainage pathways across the landfill area appear poorly developed, although a noticeable surface drainage pathway extends to the west, toward Lake Westwind, north and west of the boat storage area (appendix A, photo 2).

A small drainage ditch constructed of earthen materials and well vegetated is also present on the east side of the landfill area (area A) along Minnesota Road (appendix A, photo 17).

The lakes surrounding the site were identified as spring-fed,(ref. 3) although Bass Lake is apparently artificially recharged, potentially with water pumped from the on-site irrigation wells (appendix A, photo 19). A concrete boat launch was constructed on Lake Westwind, and storm water runoff appears to enter the lake at that point (appendix A, photos 23 and 24). Swimming or diving in these lakes is prohibited.(ref. 2)

The area in the vicinity of the site is residential.(ref. 2) Apartment complexes and four lakes surround the site. Single-family dwellings are constructed beyond the perimeter of the lakes. The Beverly Hills Park is located south of Windmill Lake. A chain-link fence constructed along the southern boundary of Windmill Lake is breached (appendix A, photo 9). Access can be obtained to Windmill Lake from the Beverly Hills Park.

WASTE CONTAINMENT/HAZARDOUS SUBSTANCE IDENTIFICATION

According to the characterization of the site completed during the PA, the primary contaminants of concern are benzene, toluene, ethyl benzene, 2-nitropropane, chlorobenzene, cyclohexane, xylene, aniline, naphthalene, 1,4-dichlorobenzene, 1,1′-diphenylhydrazine, N-nitrosodiphenyl amine, 2-methyl phenol, 2,4-dimethyl phenol, 2-3 dimethyl phenol, diethyl phthalate, styrene, and metals.(ref. 1) In addition, wood, paper, plastics, rubber, metal, neoprene, Styrofoam, urethane, PVC pellets, plastic resin, asbestos, oil-contaminated filter cake, asphalt, and municipal garbage were disposed of at the site and can be considered contaminants of concern.(ref. 1)

To address the chemicals of concern, EPA-stipulated Contract Laboratory Program (CLP) analytical methods were requested on all pathway samples collected during this SSI. A formal list of these analytical methods is specified under the CLP routine analytical services (RAS) contract. The CLP methods cover a wide range of analytes, including priority pollutant volatile and semivolatile organic compounds, metals, pesticides, and PCBs.

The only known potential source of contamination at this site is the disposed waste described above.(ref. 1) Potential means of migration include the leachate produced within the closed landfill (disposal pit), light hydrocarbon gases (methane) produced by organic waste decomposition, and volatile constituents migrating through the vadose soil zone and into the atmosphere.(ref. 1) Numerous investigations have shown that in nonarid regions, infiltration of water through buried refuse can cause water table mounding within or below a landfill.(ref. 7) Water table mounding causes leachate to flow downward and outward from the landfill. Downward flow of leachate may threaten groundwater resources. Outward flow normally causes leachate springs at the periphery of the landfill or into surface water bodies.(ref. 7)

The in-place thickness of the disposed materials varies from 1 to 16 feet, with the deepest portion of the excavation near the southwest corner.(ref. 1) The thickness of the final cover varies from less than 6 inches over large, central portions of the area to over 6 feet in areas along the north side of the closed landfill(ref. 1) During construction of the Windmill Lakes Subdivision, Windmill Lakes Boulevard was constructed over the landfill site.(ref. 1) The landfill cap was disturbed by surveying and construction, exposing waste material which was subsequently covered.(ref 1)

As mentioned, a potential problem is light hydrocarbon (methane) gas emissions generated from organic wastes deposited in the landfill. The thin cover over large portions of the fill, coupled with poor compaction of the waste materials within, will tend to promote gas migration through the surface of the landfill and into the atmosphere.(ref. 1) Since methane is flammable at concentrations of 5 to 15 percent (volume) in air, escape of the gas from the landfill could present a potential fire risk especially if allowed to collect under structures.(ref. 1) During the site visit, several areas of thin landfill cover, especially in the vicinity of monitoring well number 10, exhibited what appeared to be organic odors similar to mercaptans added to natural gas (appendix A, site photos 32 and 33).(ref. 2)

Resource Engineering, Inc. (REI) (hired by Levering & Reid) and the City of Houston Public Health Department conducted joint groundwater sampling at the site in 1982 and 1983.(ref. 1) Groundwater sample results indicated elevated concentrations of total suspended solids (TSS), and total organic carbon (TOC), high chemical oxygen demand (COD), and the presence of benzene, toluene, and several complex organic compounds in the monitoring wells sampled.(ref. 1) Concentrations of contaminants and indicator parameters reported during the well sampling program are summarized as follows:

- TSS ranged from 420-17,770 mg/L.
- COD ranged from 0-2,400 mg/L.
- TOC ranged from 64-313 mg/L.

The concentration ranges for identified contaminants of concern found in analyses of the landfill leachate (well 6) and surrounding groundwater (wells 1, 2, and 5) were: (Complete tables of the analytical results are in appendix D)

- Benzene (0.01-0.24 μg/L)
- Toluene (0.05-96.00 μg/L)
- Ethylbenzene (0.08-175.41 μg/L)
- 2-Nitropropane (0.19 μg/L)
- Chlorobenzene (3.53 μg/L)
- Cyclohexane (2.12-287.16 μg/L)
- Xylene (9.30-1,853.40 μg/L)
- Aniline (4,285.2 μg/L)
- Napthalene (0.10-24.10 μg/L)

- 1,4-Dichlorobenzene (7.10 μg/L)
- 1,1′-Diphenylhydrazine (943.9 μg/L)
- N-nitrosodiphenyl amine (1.00-126.6 μg/L)
- 2-Methyl phenol (191.00 μg/L)
- 2,4-Dimethyl phenol (9.20 μg/L)
- 2,3-Dimethyl phenol (2.70 μg/L)
- Diethyl phthalate (1.20-14.20 μg/L)
- Styrene (831.8 μg/L).

In 1983 detectable levels of extractable priority pollutants were present in the leachate samples collected from the landfill; however, the leachate was not determined to be hazardous according to Resource Conservation and Recovery Act (RCRA) standards.[ref. 1] Ten aliphatic hydrocarbons (oil constituents and/or stable organic decomposition products), fourteen fatty acids; and eleven RCRA-listed organic compounds (toluene, xylene, aniline, naphthalene, 1,4-dichlorobenzene, 1,1′-diphenylhydrazine, N-nitrosodiphenyl amine, 2-methyl phenol, 2,4-dimethyl phenol, 2,3-dimethyl phenol, and diethyl phthalate) were also detected in the leachate.[ref. 1]

Six leachate samples were obtained from monitoring well 6, near the center of the landfill, from September through December 1982.[ref. 1] The maximum concentrations representing measured leachate characteristics were:

TDS	14,177 mg/L
Sulfate (SO_4)	790 mg/L
Manganese (Mn)	8.80 mg/L
Iron (Fe)	313 mg/L
Sodium (Na)	2,772 mg/L
Chloride (Cl)	4,140 mg/L
TOC	3,976 mg/L

The City of Houston, the TWC District 7 office, and the FDIC, through Ameresco Management, participated in a joint groundwater, surface water, and lake sediment sampling program during December 1991 and February 1992.[ref. 4] Existing monitoring wells were sampled on December 11, 1991. Sediment, soil, and lake samples were collected on February 20, 1992. The sample locations are indicated on Figure 4.[ref. 1] The results of the analytical program are summarized in appendix D, tables 1 through 9, covering metal and water quality data and detected organic compounds.

Acetone was detected during the QA/QC analysis for the December 11, 1991, sampling program. The presence of acetone in the sample could have resulted from acetone contamination of laboratory instruments and/or the laboratory sample containers.[ref. 5] Additional sample data developed during this SSI may be used to determine if the presence of acetone is a laboratory artifact.

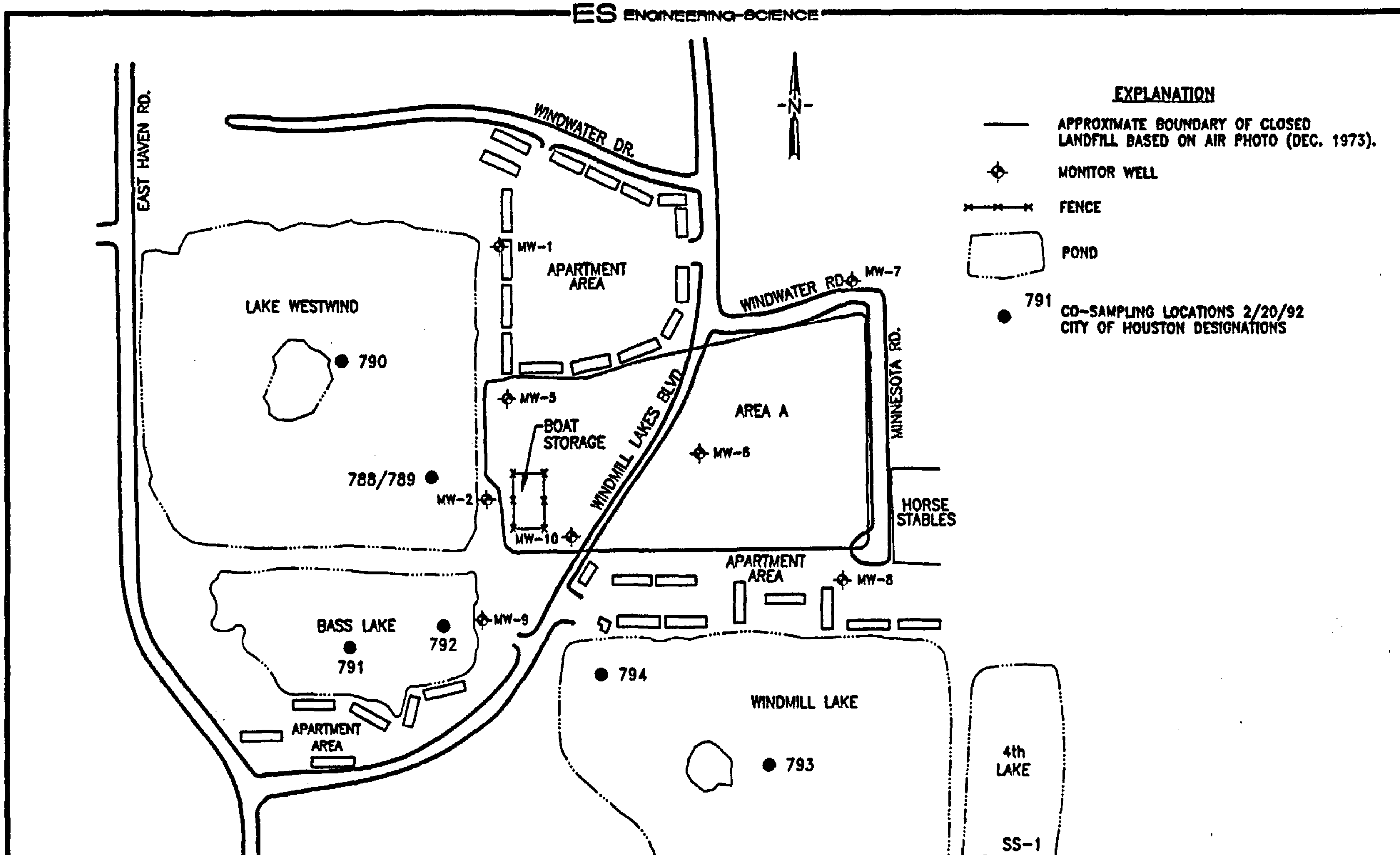

FIGURE 4
SAMPLE LOCATIONS FROM PREVIOUS INVESTIGATIONS
MOBILE WASTE CONTROLS
TEXAS WATER COMMISSION

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Required Information (Data Gaps)

No CLP data exist which characterizes the waste constituents in the disposal pit. Collection of subsurface soil samples or landfill (source) samples was beyond the scope of this investigation.

GROUNDWATER PATHWAY

Characteristics

The Houston area is situated on the Quaternary Coastal Plain of Texas.[ref. 8] Specifically, the site is underlain by the Pleistocene-age Beaumont Formation.[ref. 9] The Beaumont Formation beneath the site is described as barrier island and beach deposits consisting of mostly clay, silt, and sand. The mapped geologic unit is mainly stream or river channel, point bar, natural levee, and backswamp deposits and, to a lesser extent, coastal marsh and mud flat deposits with concentrations of calcium carbonate, iron oxide, and iron manganese oxide nodules in zones of weathering.[ref. 8] The soils beneath the site have been mapped as relict fluvial and deltaic deposits, sand units, locally clayey, easily excavated, with low to moderate erosion potential, low shrink-swell potential, high bearing strength, moderate permeability, and low to moderate moisture retention at the surface.[ref. 9]

The site is underlain by the Chicot aquifer, which is the youngest aquifer of the Coastal Plain of Texas as indicated by the stratigraphic cross-section C-C′.[ref. 10] The Chicot aquifer is composed of the Willis Sand, Bentley and Montgomery Formations, Beaumont Clay, and any overlying Holocene alluvium. In the vicinity of the site, the Chicot aquifer reaches an average thickness of approximately 600 feet.[ref. 10] Wells in the vicinity of the site are screened in saturated intervals ranging from 98 to 1,000 feet below surface. Water levels in these wells range from depths of 8.5 to 260 feet below ground surface.[ref. 1]

The local stratigraphy and depth to groundwater were determined during site evaluation activities performed at the site by REI during 1982 and 1983.[ref. 1, Atch.7] Six soil borings were logged and completed as monitoring wells during this investigation. The general subsurface stratigraphy beneath the site is alternating layers of clay and sand.[ref. 1] Generally, the uppermost interval, ranging from 7 to 9 feet in thickness, is described as a sandy clay. Beneath this interval is a clayey sand to silty sand unit ranging from 4 to 20 feet in thickness. The stiff, reddish-brown clay interval beneath the sand interval ranges from 10 to 12 feet thick, and the sand unit beneath the reddish-brown clay interval ranges from 2 to 10 feet thick.[ref. 1, Atch. 7] All monitoring wells constructed at the site by REI were screened across this uppermost saturated interval approximately 8 to 25 feet below ground surface.[ref. 1] Table 1 summarizes monitoring wells construction details.[ref 1]

The monitoring well water levels in the sandy stratigraphic interval screened in wells 2, 3, and 5 correlated with the water levels recorded from Lake Westwind.[ref. 1] In addition, a shallow groundwater mounding effect was reported beneath the covered landfill area, potentially contributing to contaminant migration from the landfill to the west and southwest.[ref. 1] According to a resistivity survey completed by REI, the depth of the landfill excavation averages 13 feet and attains a maximum

Table 1. Mobile Waste Controls
Summary of Well Construction Details for Monitoring Wells(ref. 1)

Well ID	Boring Depth (feet)	Well Material	Screened Interval (feet)	Screen Length (feet)	Well Diameter (inches)
MW-1	20	PVC	5-15	10	4
MW-2	25	PVC	8-18	10	4
MW-3	29	PVC	6-24	18	4
MW-4	23	PVC	8-20	12	4
MW-5	17	PVC	12.5-17	4.5	4
MW-6	16	PVC	6-16	10	2

* As-built well diagram (reference 1, attachment 7) indicates well diameter is 4 inches, although diagram scale used resembles 2-inch-diameter well

depth of 16 feet in the southwest corner of the excavation.(ref. 1) Shallow groundwater, occurring from 8 to 15 feet below surface in the area of the pit excavation (based on monitoring well depths), could therefore come in contact with and potentially be contaminated by the buried waste materials.(ref. 1)

The municipal or domestic wells located nearest to the site are screened at intervals of 85 to 105 feet below ground surface.(ref. 1) These wells were installed for domestic or irrigation water use. (ref. 1) Average groundwater yield for the water wells near the site in the saturated interval from 85 to 105 feet below surface is approximately 30 gpm (Table 2). The general groundwater flow direction in the vicinity of the site mimics geologic dip and is toward the southeast.(ref. 10) The saturated intervals encountered while drilling in the vicinity of the site are all considered part of Chicot aquifer.(ref. 10) According to available driller's logs, wells are screened at three primary depths in the Chicot aquifer, 8 to 25 feet (monitoring wells), 88 to 103 feet, and 440 to 470 feet below surface. Groundwater quality data for the shallow saturated interval in the vicinity of the site are reported above. Static water levels recorded on water well drilling records for the domestic wells located on East Haven and Lambright roads were reported to be 27 feet below surface.(ref. 1) These two wells were drilled and completed in what is apparently an equivalent thick sand deposit that was mined at the site. The excavated sand pits are now water filled and used for recreational purposes.(ref. 1) The water well drilling records identify sand and clay depths and thicknesses encountered while drilling. Both wells averaged a sand percentage ranging from 75 to 85 percent.

Results of subsurface soil testing conducted prior to the construction of the Windmill Lakes Subdivision and Windmill Lakes Boulevard indicate that the uppermost sandy clay (occurring at approximately 8 feet below ground surface) is a low-plasticity clay with liquid limits of approximately 28 percent and a plasticity index (PI) of approximately 16 percent. The percentage of soil particles passing the number 200 sieve was approximately 60 percent. The clayey to silty sand interval beneath the uppermost sandy clay consists of approximately 93 to 70 percent soil grains that do not pass through a number 200 sieve. This interval was saturated during soil boring activities; depth to water ranged from 5.5 to 12.5 feet below surface. The clayey to silty sand interval exhibited a laboratory vertical permeability in the range of 1×10^{-5} centimeters per second (cm/sec).(ref. 1)

The clay interval beneath the clayey to silty sand unit occurs at approximately 25 feet below ground surface. This clay exhibited liquid limits which ranged from 60 to 85 percent, plasticity indices ranging from 39 to 57 percent, and 96 percent of the clay samples analyzed not passing the number 200 sieve. The clay samples tested exhibited a laboratory vertical permeability in the range of 1×10^{-9} to 7×10^{-8} cm/sec.(ref. 1)

The potential for releases of contaminants to the groundwater pathway was assessed by collecting eight samples. Four monitoring wells (MWs) and three nearby domestic drinking water wells were sampled during the site investigation. The groundwater sample locations are shown on Figure 5. The four monitoring wells are located in the immediate vicinity of the disposal pit (area A) and are designated MW-1, MW-2, MW-8 and MW-10 (sample numbers GW-8, GW-5,

Table 2. Mobile Waste Controls, Water Wells within 1 Mile

Well ID and Location	Well Total Depth (feet)	Screened Interval (feet)	Total Sand/Gravel Thickness* (feet)	Total Clay Thickness (feet)	Static Water Level (feet)	Chemical Analysis	Flow Rate	Well Use
65-31-1C 10121 Windmill Lakes Blvd. Houston, TX	470	440-470	208	262	200	No	NA	Irrigation
65-22-6 10121 Windmill Lakes Blvd. Houston, TX	470	440-470	208	262	200	No	NA	Irrigation
65-31-1E 10039 Radio Road Houston, TX	450	440-450	126	321	160	No	25 gpm jetted	Domestic
65-31-1E 10035 Radio Road Houston, TX	103	93-103	61	40	10	No	30 gpm jetted	Domestic
65-31-1B 9913 Easthaven Houston, TX	94	88-94	81	11	27	No	500 gph deepwell jet	Domestic
65-31-1C 9421 Lambright Houston, TX	94	88-94	74	19	27	No	900 gph deepwell jet	Domestic
65-31-1L 11400 Gulf Freeway Houston, TX	90	88-90	26	64	12	No	NA	Domestic
65-31-4C 9905 Radio Road Houston, TX 77075	345	325-345	105	237	190	No	25 gpm jetted	Domestic
65-30-3F 10305 Moers Houston, TX 77075	231	90-100	61	166	12	No	35 gpm jetted	Domestic
65-30-3E Lambright Houston, TX	98	90-98	58	37	6	No	125 gpm blow w/ compressor by drills	Domestic

* Does not include fill or topsoil

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Table 2, continued

Well ID and Location	Well Total Depth (feet)	Screened Interval (feet)	Total Sand/Gravel Thickness* (feet)	Total Clay Thickness (feet)	Static Water Level (feet)	Chemical Analysis	Flow Rate	Well Use
65-30-3E 9917 Radio Road Houston, TX 77034	348	347½-348	121	224	190	No	75 gpm jetted	Domestic
65-30-3E 9718 Moers Road Houston, TX 77037	87	80-87	52	35	18	No	NA	Domestic
65-30-3F Lambert Houston, TX	348	338-348	86	259	183	No	60 gpm jetted	Industrial
65- -3F Mykowia Road Houston, TX	94	86-94	37	55	18	No	35 gpm air compressor	Domestic
65-23-7F 9731 Radio Road Houston, TX 77034	352	325-340	113	235	170	No	13 gpm submersible	Domestic
65-23-7G 11412 Gulf Freeway Houston, TX	350	330-350	50	295	185	No	NA	Domestic
65-22-9R 9924 Radio Road Houston, TX 77075	105	95-105	73	29	29	No	15 gpm jetted	Domestic
65-30-3 9215 Wayfarer Houston, TX	454	444-454	81	370	215	No	75 gpm jetted	Domestic
65-15-4 9825 Radio Road Houston, TX 77075	340	330-340	62	275	175	No	30 gpm jetted	Domestic

* Does not include fill or topsoil

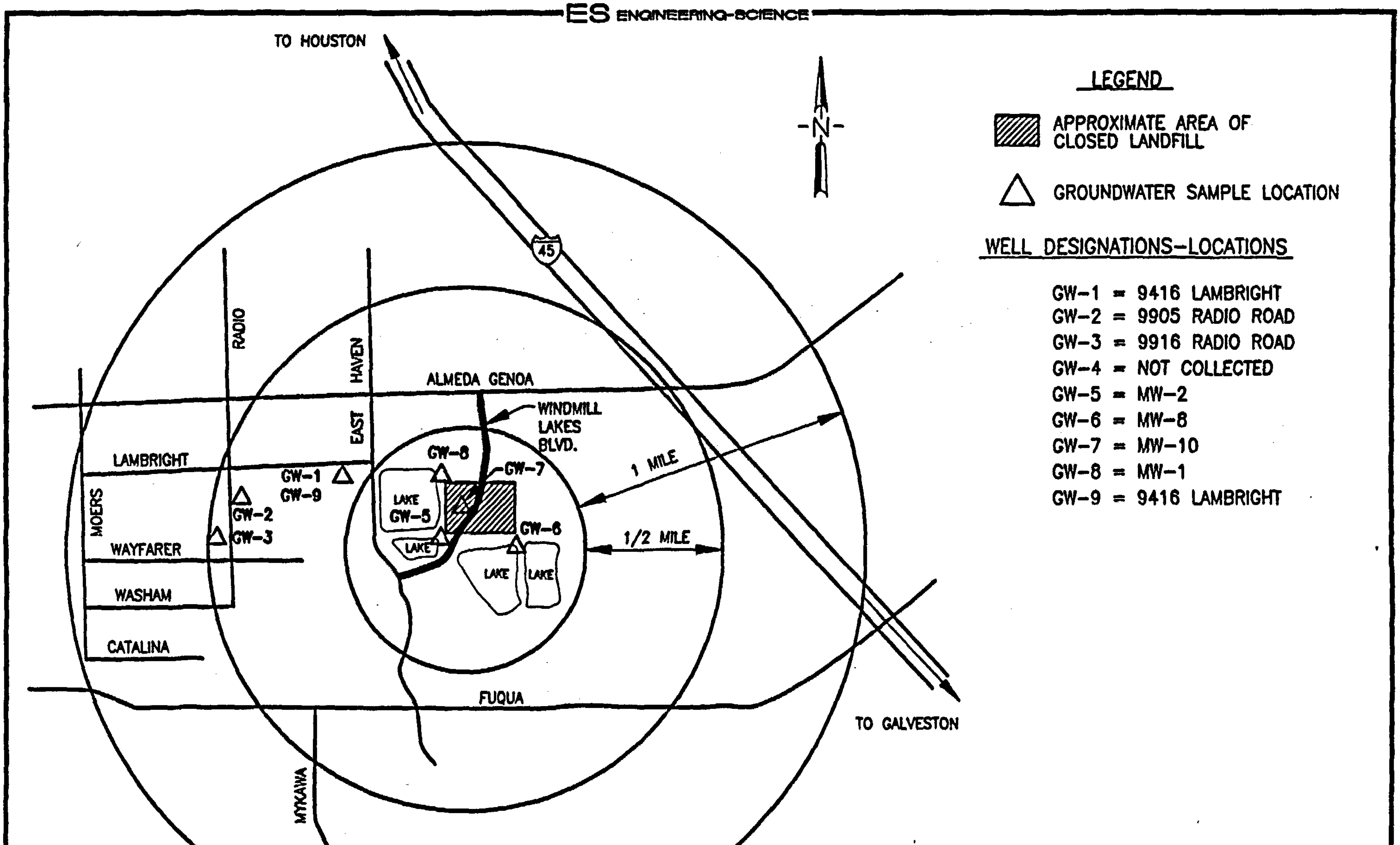

FIGURE 5

GROUNDWATER SAMPLING LOCATIONS

MOBILE WASTE CONTROLS

TEXAS WATER COMMISSION

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GW-6, and GW-7, respectively). Three monitoring wells (MW-1, MW-2, and MW-8) are located on the periphery of the disposal pit and provide data for the uppermost water-bearing zone to assess the potential outward migration of contaminants from the pit into the shallow groundwater and potentially into the adjacent lakes. MW-10 was constructed inside the disposal pit and provides data which can be used to characterize the groundwater directly beneath the disposed material.

Three domestic water wells were sampled: one at 9416 Lambright Rd (GW-1), owned by [redacted] and screened at 160 feet below surface; one at 9905 Radio Road (GW-2), owned by [redacted] and screened at 360 feet below surface, and one at 9916 Radio Road (GW-3), owned by [redacted] and screened at 115 feet below surface. GW-9 was collected as a duplicate QA/QC sample from the domestic well at 9416 Lambright Road. All three of these wells were located within ½ mile to the west of the site. Two domestic water wells which were located within ¼ mile of the site were originally scheduled for sampling. However, these wells were recently abandoned by the owners after connecting to the City of Houston water supply. No problems were reported with the well water.

Before onsite monitoring wells were sampled, each well was purged as specified in the work plan. Either three well volumes were purged, or the wells were bailed dry. The wells were sampled with dedicated Teflon bailers that were decontaminated prior to use. Purge waters were collected in 55-gallon drums by representatives of Ameresco Management, Inc., for eventual disposal. Photographs 27, 28, and 29 show the locations of MW-2, MW-8, and MW-1, respectively. The domestic wells were allowed to run for a minimum of 15 minutes before sampling. Samples GW-1, GW-3, and GW-9 were collected directly from the well tap. Sample GW-2 was collected from the tap closest to the well house located outside Mr. Kuykendall's home. Photographs 38 through 41 show the taps from which the samples were collected. Samples were collected directly into approved sample bottles and packed in coolers on ice for next day delivery to the designated CLP laboratory. The samples were analyzed for CLP volatile and semivolatile organics, CLP pesticides/PCBs, CLP metals, and cyanide.

Targets

Two hundred seventy-eight private, irrigation, industrial, municipal and monitoring wells are located within a 4-mile radius of the site.[ref. 1] Sixteen private and irrigation wells are located within a 1-mile radius of the site. In addition, eight monitoring wells were installed within the 1-mile radius of the site to monitor local groundwater quality. Static water level measurements for these wells, including monitoring wells, ranged from 6 to 215 feet below surface. The wells were completed within the Chicot aquifer.[ref. 1] A summary of the characteristics of the wells located within a 1-mile radius of the site is presented as Table 2. One wellhead protection area is within a 4-mile radius of the site, the City of Houston Sagemont #2 well located approximately 2 miles southeast.[ref. 1]

There is no analytical evidence indicating that any drinking water well has been contaminated by hazardous substances from the site.[ref. 12] In October 1991, a domestic well located at 9917 Radio Road was sampled by the TWC and analyzed for total organic compounds (TOC) and metals. The TWC reported less than 5 ppm TOC and no metals in the sample collected.[ref. 1] Several drinking water samples were collected as part of this investigation. The analytical results for these samples are in part 2 of this report.

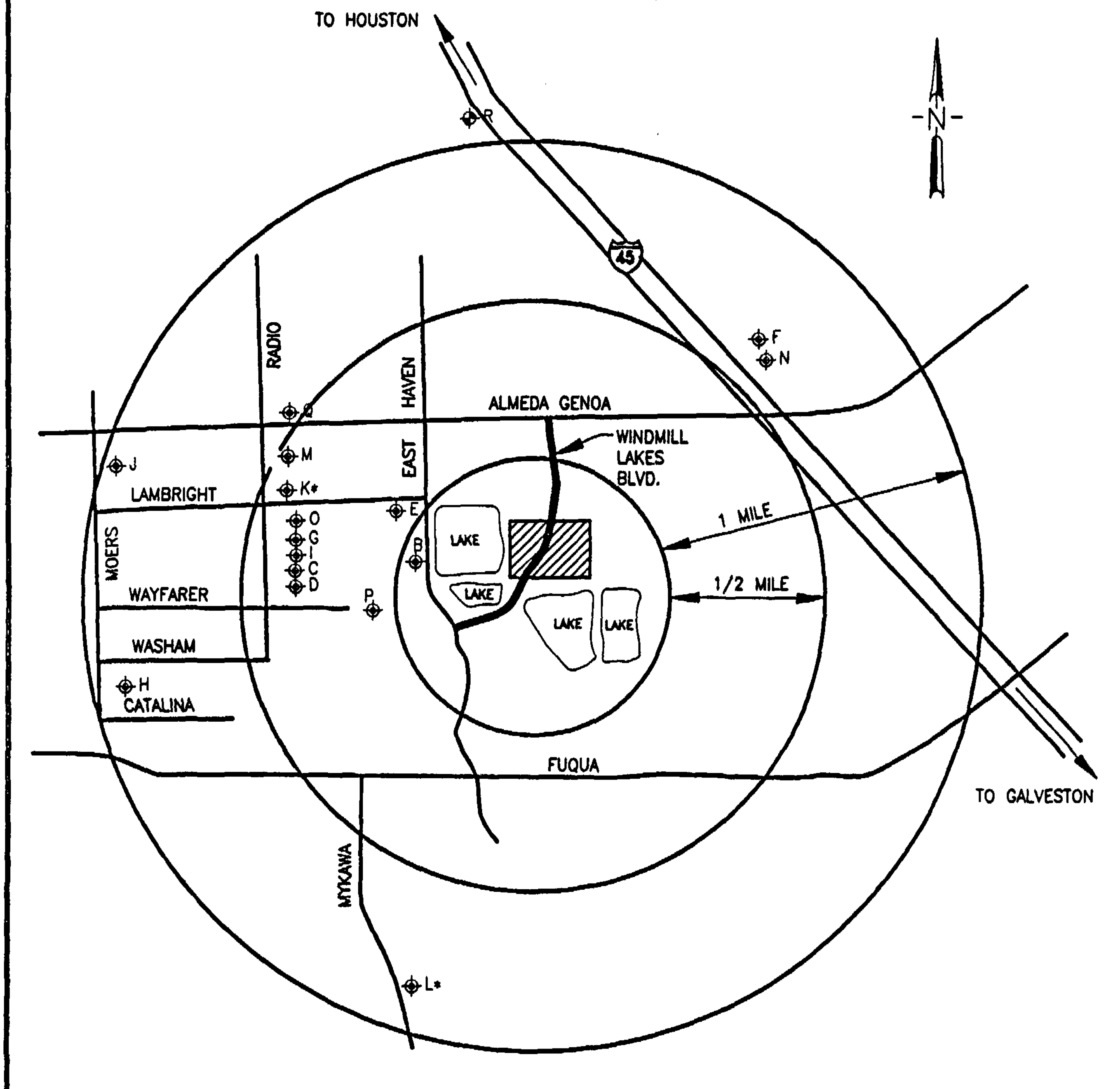
For wells within a 4-mile radius of the site:[ref. 1]

- Within 0 to 0.25 mile of the site there are two domestic wells, two irrigation wells, and eight monitoring wells.
- Between 0.25 and 0.50 mile, there are seven private wells.
- Between 0.5 and 1.0 mile, there are seven private wells.
- Between 1.0 and 2.0 miles, there are four municipal supply wells, seventy private wells, eight industrial wells, and three monitoring wells.
- Between 2.0 and 3.0 miles, there are four municipal supply wells, fifty-nine private wells, and eleven industrial wells.
- Between 3.0 and 4.0 miles, there are six municipal supply wells, seventy-six private wells, and thirteen industrial wells.
- There are fourteen municipal supply wells within the 4-mile radius of the site.[ref. 1]

The locations of the domestic wells located within 1 mile of the site are indicated on Figure 6.[ref. 1] Details of well construction, well use, pumping rates, thicknesses of the sand and clay intervals of the Chicot aquifer, and static water levels for wells located within 1 mile of the site are summarized in Table 2.[ref. 1] The screened intervals of wells in the vicinity of the site, excluding monitoring wells, range from 80 to 470 feet below ground level. Logs of wells in the vicinity of the site describe the formation as alternating layers of sand and clay of the Chicot Formation. The well constructed through the greatest thickness of sand is located at 9913 East Haven Road in Houston, Texas. This well is within 0.25 mile of the site. The static water level of this well was 27 feet below ground surface. A pump test was not conducted during well construction and development.[ref. 1] Approximately thirty-nine people are served by the sixteen domestic wells within 1 mile of the site, using the population factor (2.4 residents per household) developed during the PA.[ref. 1] One well provides drinking water for a Houston Lighting & Power Company substation approximately 3/4 mile from the site. Based on a minimum of a three-man crew per day using the facilities, the potential number of targets per year is 1,095. The groundwater population target calculations for distance increments were performed for the area within 1 mile of the site and are shown in Table 3.[ref. 1] The area around the site is currently converting to the city water supply system, so dependence on a domestic supply of water should therefore decrease in the near future.

The sources of the City of Houston and Kirkmont MUD municipal water supply in the vicinity of the site are Houston-Galveston Coastal Subsidence District (HGCSD) well numbers 1094 and 1717.[ref. 1] The population served by this water supply is 9,843.[ref. 1] This information is summarized in Table 3.

ES ENGINEERING-SCIENCE



LEGEND

* UNDOCUMENTED HOUSE NUMBERS LOCATION TO BE VERIFIED

NA NOT AVAILABLE

MONTORING WELL LOCATION

DOMESTIC SUPPLY WELL LOCATION

APPROXIMATE AREA OF CLOSED LANDFILL

WELL DESIGNATIONS–ADDRESSES

B – 9913 EAST HAVEN
C – 10035 RADIO RD.
D – 10039 RADIO RD.
E – 9421 LAMBRIGHT
F – 11,400 GULF FREEWAY
G – 9905 RADIO RD.
H – 10305 MOERS RD.
I – 9917 RADIO RD.
J – 9718 MOERS RD.
K – NA LAMBRIGHT RD.*
L – NA MYKAWA*
M – 9731 RADIO RD.
N – 11412 GULF FREEWAY
O – 9924 RADIO RD.
P – 9205 WAYFARER
Q – 9625 RADIO RD.
R – 3MW I45/CLEARWOOD

FIGURE 6

WELLS WITHIN 1 MILE RADIUS OF SITE

MOBILE WASTE CONTROLS

TEXAS WATER COMMISSION

S10-WELL 9/17/92

Table 3. Mobile Waste Controls, Groundwater Population Targets

Mile Radius	Type of Well	Number of Wells	Total Target Population *	Notes
0.00-0.25	Domestic	2	5	• HGCSD well 1040, 0.17 mile from site, plugged in the 1970s.
	Public supply	0	0	
	Industrial	0	0	
	Irrigation	2	0	
	Monitoring	6	0	
	Total	10	5	
0.25-0.50	Domestic	7	17	
	Public supply	0	0	
	Industrial	0	0	
	Irrigation	0	0	
	Total	7	17	
0-50-1.00	Domestic	7	17	• HGCSD well 1048, 0.93 mile from site, plugged in 1991.
	Public supply	0	0	• HGCSD well 1202, 0.76 mile from site. Estimated 42,000 gallons annual production. Rest rooms used by HL&P crews 7 days per week; minimum of one three-person truck crew uses station each day. Three people times 365 days = target 1,095.
	Industrial	1	1,095	
	Irrigation	0	0	
	Total	8	1,112	
1.00-2.00	Domestic	70	168	• HGCSD well 1134, 1.23 miles from site, plugged prior to 1980.
	Public supply	2	9,843	• HGCSD well 1059, 1.87 mile from site, plugged prior to 1980.
	Industrial	8	0	• HGCSD well 1094, 1.88 miles from site. Standby well to provide water to the Sagemont area (approximately 5 square miles) if the surface water distribution line fails. Well can produce 850 gpm. 5 square miles times 1,584.62 residents per square mile for Harris County = target 7,923.
	Irrigation	0	0	• HGCSD well 1717, 1.96 miles from site. Public supply well with approximately 800 connections. 800 times 2.4 residents per Harris County household = target 1,920.
	Monitoring	3	0	
	Total	83	10,011	

* Population factor for Harris County is 2.4 residents per household.

Required Information (Data Gaps)

- Analysis of the groundwater samples collected for this investigation had not been completed as of the writing of part 1 of this report. The analytical results are discussed in part 2 of this report.
- Monitoring well survey data were not available; hence, current groundwater flow direction could not be adequately determined.
- No subsurface soil samples were collected during SSI activities to characterize subsurface soil conditions. Collection of subsurface soil samples was beyond the scope of this investigation.

SURFACE WATER PATHWAY

Characteristics

The site is located in the San Jacinto-Brazos Coastal Basin, segment 1102.[ref. 1] This segment, Clear Creek above tidal, is classified as water quality limited, is 44 miles in length, and drains an undetermined area.[ref. 13] Thirty-one permitted outfalls discharge a total of 30.44 million gallons per day (mgd) to segment 1102, specifically twenty-three domestic (30.35 mgd) and eight industrial (0.09 mgd) outfalls. There are two TWC ambient surface water quality monitoring stations, 1102.0100 and 1102.0200, for this segment, located 5.8 and 7.3 miles from the site.[ref. 13] Surface water quality data for segment 1102 are presented in Table 4.[ref. 13]

Surface drainage in the vicinity of the site is generally to the southwest, in the direction of the small lakes formed from excavated sand pits.[ref. 1] In addition, surface water drainage may also occur southwestward along Windmill Landing Boulevard toward the Harris County drainage ditch. The site is located outside the 500-year flood plain.[ref. 1] The 2-year, 24-hour rainfall event in the area of the site is 5.5 to 6.0 inches[ref. 14] with an average annual rainfall rate of 44.76 inches.[ref. 15]

The filled landfill pit (area A, Figure 2) is located north and east of four lakes created by sand quarrying operations.[ref. 1] The lakes have been filled by precipitation, surface water runoff, and groundwater seepage.[ref. 1] A potential surface water pathway exists that would allow surface water to drain across and through the fairly thin and, in places, breached landfill cap material into the nearby lakes. The probable point of entry (PPE) from surface drainage is the embankments of the lakes.

A second potential pathway is interaction between groundwater and surface water. Precipitation and ponded surface water over the landfill will infiltrate into the landfill cover, especially in areas where the cap has been breached. Groundwater mounding was reported beneath the covered landfill area.[ref. 1] The upper saturated sandy interval that intersects the sidewalls of the landfill pit could channel subsurface flow in the direction of local groundwater flow, potentially controlled by the groundwater mounding (recharge) noted during the investigations completed by REI.[ref. 1] As the potentially contaminated shallow groundwater moves under the influence of hydrostatic head, the outcrop of the saturated interval along the side

Table 4. Mobile Waste Controls October 1, 1985, Through September 30, 1987
TWC Water Quality Information for Segment 1102[ref. 12]

Parameter	Criteria	Number Samples	Minimum	Maximum	Mean	Number of Values Outside Criteria	Mean Values Outside Criteria
Dissolved oxygen (mg/L)	5.0	27	4.5	17.0	8.4	3	4.8
Temperature (°F)	95.0	27	54.3	87.8	72.1	0	0
pH	6.5 - 9.0	24	7.1	8.6	7.9	0	0
Chloride (mg/L)	200	27	31	224	137	2	218
Sulfate (mg/L)	100	25	21	120	43	1	120
Total dissolved solids (mg/L)*	600	25	191	630	492	2	626
Fecal coliforms (#/100 mL)	200	25	10	15,000	231	15	619

* Total dissolved solids were estimated by multiplying specific conductance by 0.50.

walls of the four excavated sand pit areas, now lakes, may form seeps or springs that feed the surface waters of the lakes.

The topography of the site indicates a mounding in the general location of the closed landfill.(ref. 1) Reportedly, the landfill area is slightly raised by postclosure activities.(ref. 1) The topographic land surface reaches a maximum of 48 feet (MSL) and falls to approximately 40 feet MSL near the northern extremity of the site. South and west of the closed landfill area, the land surface is approximately 44 feet MSL so that surface water drainage patterns are west and south of the area of the landfill cap.(ref. 1) Surface runoff appears to flow into the lakes located to the west and south of the closed landfill area.

Surface water runoff which does not enter the lakes flows to a Harris County Water Control and Improvement District (WCID) drainage ditch. This drainage ditch is designated as intermittent on the USGS topographic map.(ref. 18) Since the drainage ditch is intermittent, as confirmed during field activities,(ref. 2) no surface water pathway exists from the site to Clear Creek. The distance along the drainage ditch to Clear Creek is approximately 5 miles.

Four sediment samples (photos 19, 20, and 23) and five surface water samples (photos 18, 21, 25, and 30) were collected on October 14, 1992, to assess the potential for releases to the surface water pathway. In addition, one soil sample, SO-7 (photo 17), was obtained from a drainage ditch located along the eastern boundary of the site. This soil sample was obtained to evaluate the potential migration of contaminants from the landfill through the ditch. The locations of these samples are shown in Figure 7.

Sample SE-1 was collected from atop a dock that crosses the center of Windmill Lake. The sample was taken with a dedicated Eckman dredge sampler which was decontaminated prior to use. The samples were retrieved from the pond bottom approximately 10 to 15 feet below the surface. Samples SE-2, SE-3 and SE-4 were collected from a boat using dedicated brass Lamotte bottom sampling dredges that were also cleaned prior to use. SE-3 was collected as a composite sample from several locations and depths in Bass Lake. SE-2 and the QA/QC duplicate sample (SE-4) were collected as grab samples approximately 100 feet north of south bank in Lake Westwind at a depth of approximately 25 feet.

The surface water samples were all collected from the upper 6 inches of water using dedicated polyethylene surface water dippers that were decontaminated prior to use. The sample was poured directly into approved sample bottles. SW-1 was collected from the middle of Windmill Lake from the dock that extends into the lake. SW-2 and the QA/QC duplicate sample (SW-5) were collected from the boat in Lake Westwind. SW-3 was collected from the eastern shore of Bass Lake in the vicinity of a recharge well's outflow into the lake. Lastly, SW-4 was collected from along the northern shore of a fourth unnamed lake. The samples were analyzed for CLP volatile and semivolatile organics, CLP pesticides/PCBs, CLP metals, and cyanide. Analytical results of these samples are discussed in part 2 of this report.

-24-

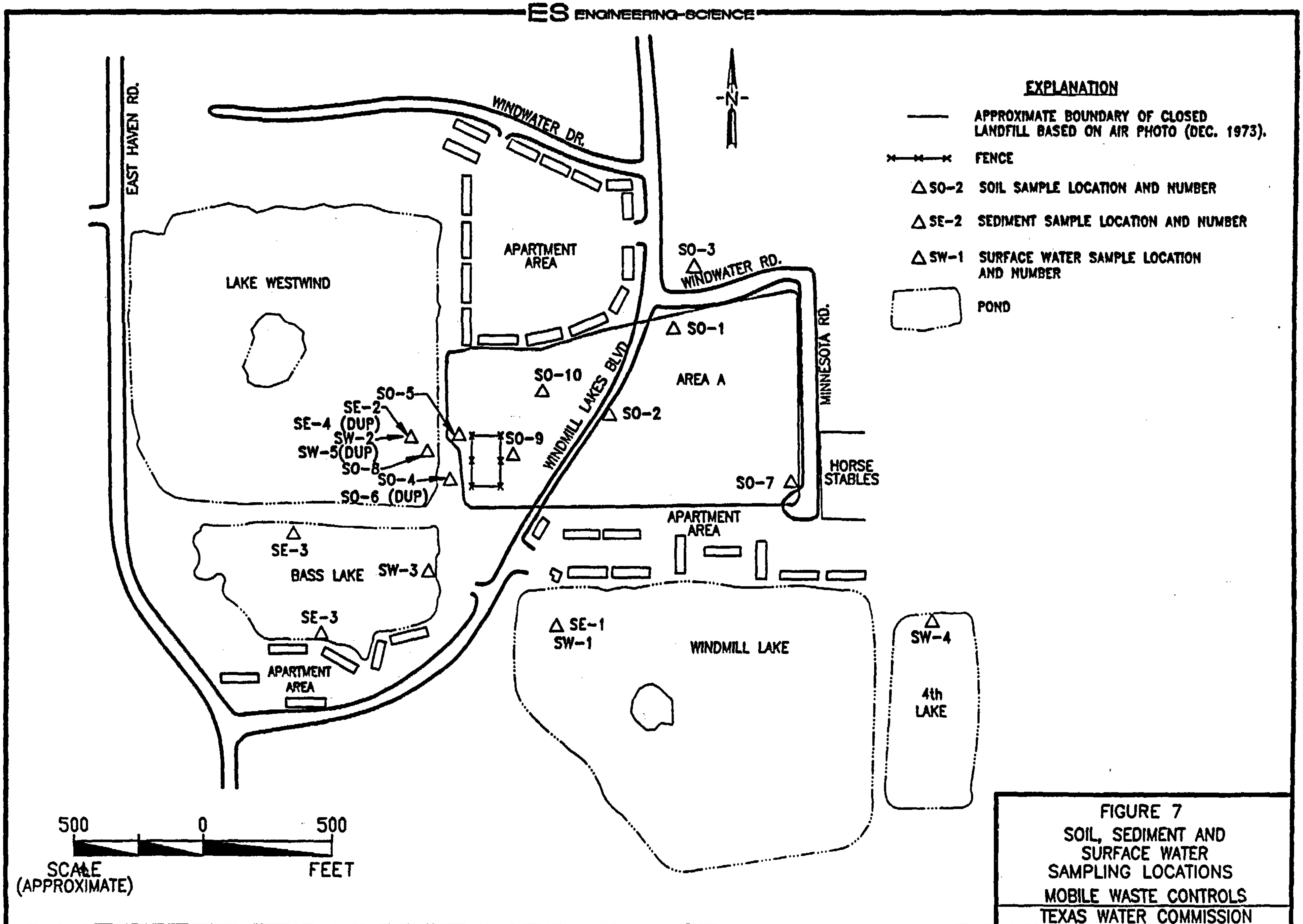


FIGURE 7
SOIL, SEDIMENT AND SURFACE WATER SAMPLING LOCATIONS
MOBILE WASTE CONTROLS
TEXAS WATER COMMISSION

S10-SAMP 12/14/92

Targets

The designated water uses for segment 1101 and segment 2425 of the San Jacinto-Brazos Coastal Basin are contact recreation.(ref. 14) Drainage discharge of Clear Creek is 26,150 acre-feet per year(ref. 1) with an average flow of about 36.1 cubic feet per second (cfs).(ref. 1) Low flow for segment 1102 is not known. The Clear Creek tidal segment, 14 miles in length, does include a portion of the 15 downstream miles from the site and is designated as a domestic water supply.(ref. 13) The lakes surrounding the site are frequently used for fishing, swimming, and boating(ref. 1)

Threatened and endangered species within a 4-mile radius of the site are *Bufo houstonensis* (Houston toad), *Tympanuchus cupido attwateri* (Attwater's greater prairie chicken), *Opheodrys vernalis* (smooth green snake), *Chloris texensis* (Texas windmill grass), *Machaeranthers aurea* (Houston machaeranthera), *Nerodia fasciata clarkii* (gulf salt marsh snake), and *Rana areolata* (crawfish frog).(ref. 1) None of these species were identified at the site during the site inspection activities(ref. 2) A list of EPA-recognized sensitive environments is in appendix C.

Required Information (Data Gaps)

- Texas Parks and Wildlife Department TPWD has not yet provided fish production estimates for the lakes and rivers in the drainage route from the site.
- Analysis of the samples collected for this investigation was not completed as of the writing of part 1 of this report. Results from these samples are reported in part 2 of this report.

SOIL EXPOSURE PATHWAY

Characteristics

During a TWC site inspection, stressed and bare vegetation areas were noted over the site and in the area of monitoring well 10 at the western edge of the closed landfill and adjacent to Lake Westwind.(ref. 1) Stressed vegetation and bare soil areas with exposed debris were noted during the SSI (appendix A, photos 3 through 8). These areas are potential soil exposure pathways and were sampled during the SSI.

The closed, 25-acre landfill site is a maintained, open, landscaped, grass field, and public access is not restricted.(ref. 1) Offsite runoff patterns are described as occurring to the southwest and potentially to the north,(ref. 1) as discussed in the surface water pathway section above.

The site is accessed by Windmill Lakes Boulevard, Windwater Road, East Haven Road, and Minnesota Road. There are no fences constructed to inhibit access to the approximately 25-acre area of the closed and capped landfill (Figure 2, area A). There is a fenced, locked, boat storage area constructed on top of the southwest corner of the closed landfill (Figure 2 and appendix A, photo 8). Access to boating on the lakes is restricted to residents of the area. Security related to the apartment complexes is not known.

Stressed vegetation and bare soil areas were identified, and hand auguring to a depth of 1 foot was attempted. East of the boat storage area in the vicinity of MW-10, clay was present at 10 inches below surface. At sample location SO-10, the cap thickness was approximately 6 inches. The clay thickness near the northernmost apartments west of Windmill Lakes Boulevard was 8 to 10 inches.

Plastic sheeting was encountered approximately 4 inches below surface in the vicinity of the soil sample location SO-1. The central portion of area A on the east side of Windmill Lakes Boulevard is covered with a hard, rocky material.

Strong odors emanated from approximately 4 inches below surface at a location on the east side of Windmill Lakes Boulevard, in the center of the southern half of area A. No organic vapor readings were taken at this location, but readings taken at other locations on the site showed no volatile organics present in the air at the site during the site visit.

Ten soil samples were collected on October 14, 1992, to assess for contaminants that may impact the soil exposure pathway. The locations of these samples are shown on Figure 4. The following samples were obtained from areas of stressed vegetation, thin landfill cap areas, and/or areas of exposed debris: SO-1 (photo 15), SO-2 (photo 16), SO-4 (photo 10), SO-5 (photo 12), SO-6 (duplicate of SO-4), SO-9 (photo 13), and SO-10. Soil sample SO-7 (photo 17), obtained from a drainage ditch on the east side of the site, was collected to assess the potential migration of contaminants from the landfill.

Soil sample SO-8 (photo 11) was obtained along the probable point of entry into Lake Westwind of potential contaminants migrating under the influence of shallow groundwater or surface water flow. Soil sample SO-3 (photo 14) was obtained north of the site and was the background soil and sediment sample (appendix A, photos 10 through 17).

Sampling was performed with dedicated trowels. The samples were collected from as close to the surface as possible, yet deep enough to avoid grass and roots. Samples were placed in glass jars as specified by the CLP and sealed with Teflon-lined lids. Organic samples were placed in one 8-ounce widemouth glass jar and two 120-milliliter widemouth glass vials. Inorganic soil samples were placed in one 8-ounce widemouth glass jar. No headspace was left in the volatile organics sample jars. Sample jars were marked for identification and placed on ice for preservation. Identification markings included site location, sample number, date and time of collection, and names of samplers. The samples were shipped to the designated CLP laboratories via next day delivery service. The samples were analyzed for CLP volatile and semivolatile organics, CLP pesticides/PCBs, CLP metals, and cyanide.

Targets

Land use adjacent to the site is residential and recreational. Three groups of apartments were constructed adjacent to the site.[ref. 1] The approximate total population of the apartments is 1,950.[ref. 1] An estimated 299 total units from the three apartment complexes surrounding the closed landfill area are located within 200 feet of the site. There are no schools within 200 feet of the site.[ref. 1] Beverly

Hills Intermediate School, with an enrollment of approximately 1,000 students, is the nearest school (0.56 mile) to the site.(ref. 17)

Terrestrial sensitive environments on or within offsite runoff pathways from the site are not known. Habitats for threatened and endangered species have been identified within a 4-mile radius of the site.(ref. 1) A list of EPA-recognized sensitive environments is in appendix C.

Threatened and endangered species within a 4-mile radius of the site are *Bufo houstonensis* (Houston toad), *Tymapanuchus cupido attwateri* (Attwater's greater prairie chicken), *Opheodrys vernalis* (smooth green snake), *Chloris texensis* (Texas windmill grass), *Machaeranthers aurea* (Houston machaeranthera), *Nerodia fasciata clarkii* (gulf salt marsh snake), and *Rana areolata* (crawfish frog).(ref. 1)

Required Information (Data Gaps)

Analysis of the soil samples collected for this investigation had not been completed at the writing of part 1 of this report. Results of these analyses are included in part 2 of this report.

AIR PATHWAY

Characteristics

Potential surface soil contamination from the contents of the closed landfill and volatile contaminants from leachate or within the closed landfill are potential sources to the air pathway. Releases of strong petroleum and chemical odors were reported from bare soil areas at the site during a November 1991 complaint investigation and were observed during the SSI.(ref. 1) Judging from wind rose information for this area, dusting is anticipated to be occasional. The wind rose for Houston, presented in Figure 8, indicates that the winds are predominantly from the south and southeast, with wind speeds of 11 to 16 knots about 10 percent of the time.(ref. 16)

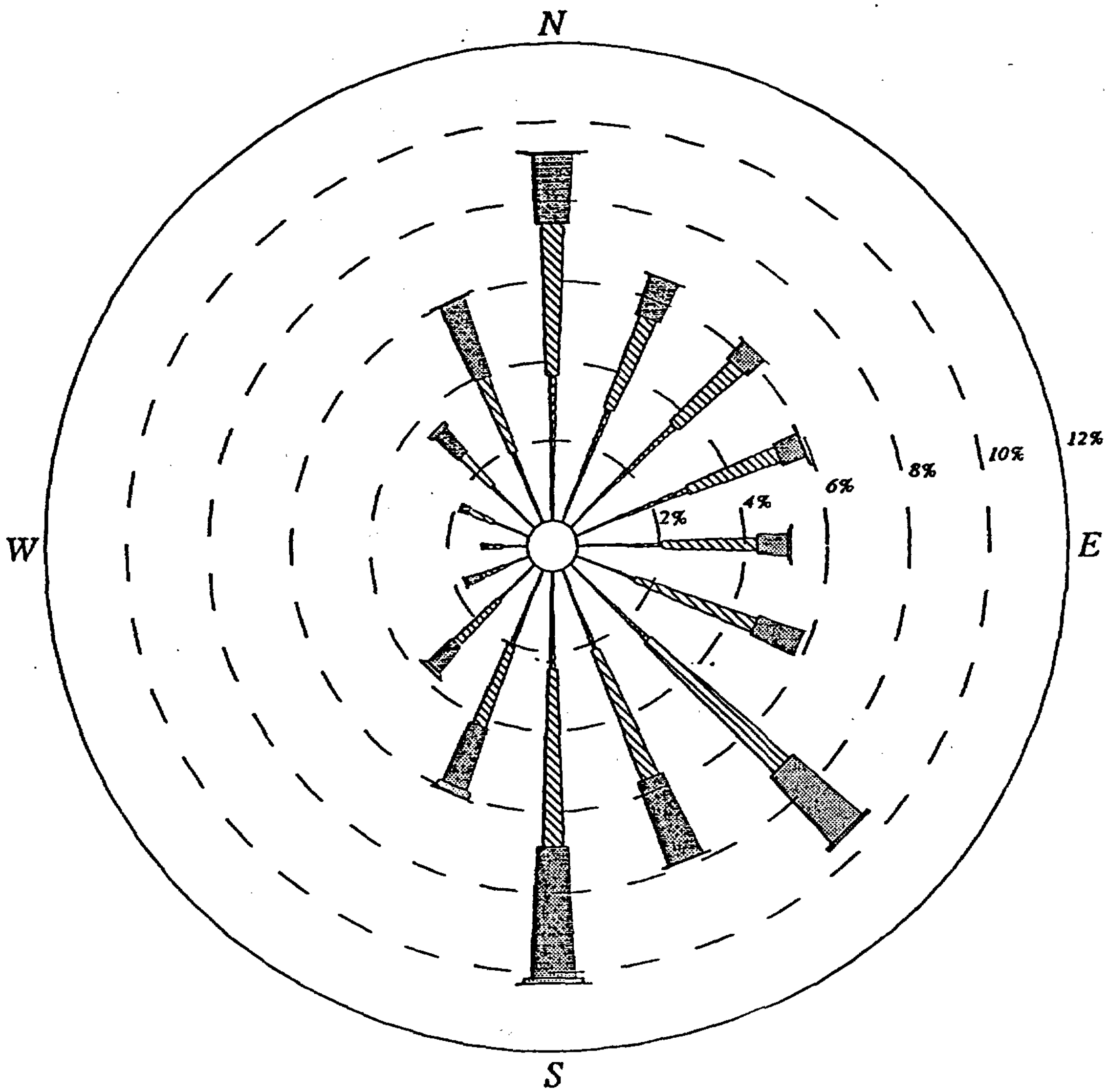
The Texas Air Control Board headquarters and District 7 (Bellaire) offices and the Houston Bureau of Air Quality Control do not have reports of observed releases from the site, reports of adverse health effects, or other records on file for the site.(ref. 17)

One surface soil sample in particular, SO-10, was collected to assess potential sources of air emissions, as it was collected from an area where an appreciable odor was observed during the SSI site visit. Soil samples SO-1, SO-2, SO-4, SO-5, and SO-6 (duplicate of SO-4) were obtained in areas of stressed vegetation, thin landfill cover thickness, or in areas documented as potentially impacted during the PA and can be used to assess potential sources of air emissions.

Targets

The population within a 4-mile radius of the site is estimated to be 50,000 people.(ref. 1) The nearest school, Beverly Hills Intermediate School (enrollment 1,000), is located about 0.56 mile southeast of Windmill Lake, one of the lakes located along the southern boundary of the site.(ref. 18) The nearest park, Beverly Hills Park, is located about 0.20 mile southeast of the site.(ref. 18) The

HOUSTON
WIND ROSE
January 1-December 31; Midnight-11 PM



CALM WINDS 9.00%

WIND SPEED (KNOTS)

NOTE: Frequencies indicate direction from which the wind is blowing.

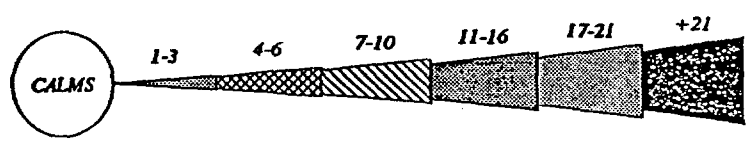


FIGURE 8

WIND ROSE

MOBILE WASTE CONTROLS

TEXAS WATER COMMISSION

location of the nearest residence is the Windmill Lakes Apartments approximately 50 feet north of soil sample location SO-10. Approximately 811 apartment units, containing 1,946 residents, are located adjacent to the site. The nearest individual subject to exposure from a release of hazardous substances through the air is not known at this time. There are no national parks or national monuments within a 4-mile radius of the site.[ref. 19] Sensitive environments have been identified as occurring within the 4-mile target distance from the site.[ref. 1] A list of EPA-recognized sensitive environments is in appendix C.

Endangered or threatened species are historically known to exist within a 4-mile radius of the site, although they have not been absolutely identified as occurring in the locality of the site.[ref. 1] Threatened and endangered species within a 4-mile radius of the site are *Bufo houstonensis* (Houston toad), *Tymapanuchus cupido attwateri* (Attwater's greater prairie chicken), *Opheodrys vernalis* (smooth green snake), *Chloris texensis* (Texas windmill grass), *Machaeranthers aurea* (Houston machaeranthera), *Nerodia fasciata clarkii* (gulf salt marsh snake), and *Rana areolata* (crawfish frog).[ref. 1] Sensitive environments have been identified during the PA within the 4-mile target distance from the site. Sensitive environments were not observed by ES field team members within a 4-mile radius of the site during the SSI site visit.

Required Information (Data Gaps)

No analytical data for the air pathway exists because the collection of air samples was beyond the scope of this investigation. Soil samples collected can be used to assess the potential for releases of hazardous substances to the air.

CONCLUSIONS

There are numerous primary contaminants of concern at this site. Industrial wastes were accepted for disposal at the site.[ref. 1] The primary contaminants of concern identified in the PA are benzene, toluene, ethylbenzene, 2-nitropropane, chlorobenzene, cyclohexane, xylene, aniline, naphthalene, 1,4-dichlorobenzene, 1,1′-diphenylhydroazine, N-nitro-sodiphenyl amine, 2-methyl phenol, 2,4-dimethyl phenol, 2,3-dimethyl phenol, diethyl phthalate, styrene, and metals.[ref. 1] In addition, wood, paper, plastics, rubber, metal, neoprene, Styrofoam, urethane, PVC pellets, plastic resin, asbestos, oil-contaminated filter cake, asphalt, and municipal garbage were disposed of at the site.[ref. 1]

Groundwater, surface water, soil exposure, and air pathways are of concern at the site.[ref. 1 and 2] The primary targets via the groundwater and surface water pathways are the apartment residents that live adjacent to and who may swim, boat, and fish in the lakes surrounding the site. (Groundwater at the site may recharge to the lakes.) Houston residents living within 1 mile of the site who rely on domestic water supplies are also potential targets.

Access to the site is not restricted, and the landfill cover, breached during the construction of Windmill Lakes Boulevard, shows evidence of waste exposure, leakage, air emissions, and erosion.

The analytical data collected during this SSI are in part 2 of this report. These data enable determinations to be made regarding releases to the groundwater, surface water and soil exposure pathways.

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18. U.S. Geological Survey map, Friendswood quadrangle, 1982.
19. National Park Service, Santa Fe, New Mexico, National Parks in Texas, brochure.
20. Shannon Breslin, Texas Department of Parks and Wildlife, communications with Carolyn Kelly, ES, December 1992.

Appendix A

Photographs

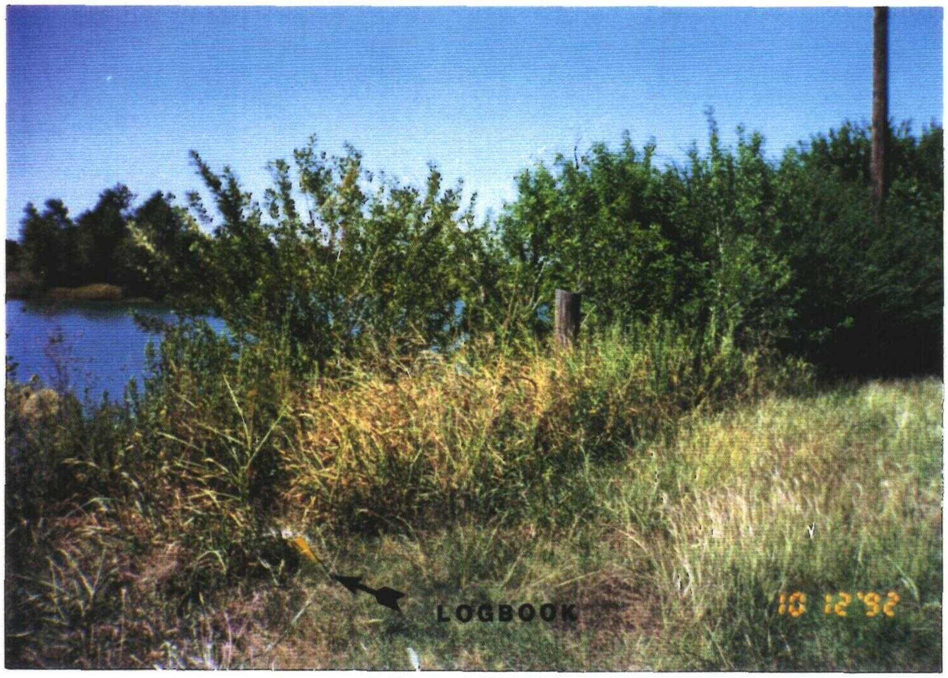


Photo 1 (10/12/92): Monitoring Well 2 location near yellow field notebook [see arrow], adjacent to Lake Westwind between Area A and the lake, facing northwest (TXD 988051652)

Photo 2 (10/12/92): Soil drainage pathway along cap adjacent to Lake Westwind, northeast corner of boat storage area, facing southeast (TXD 988051652)

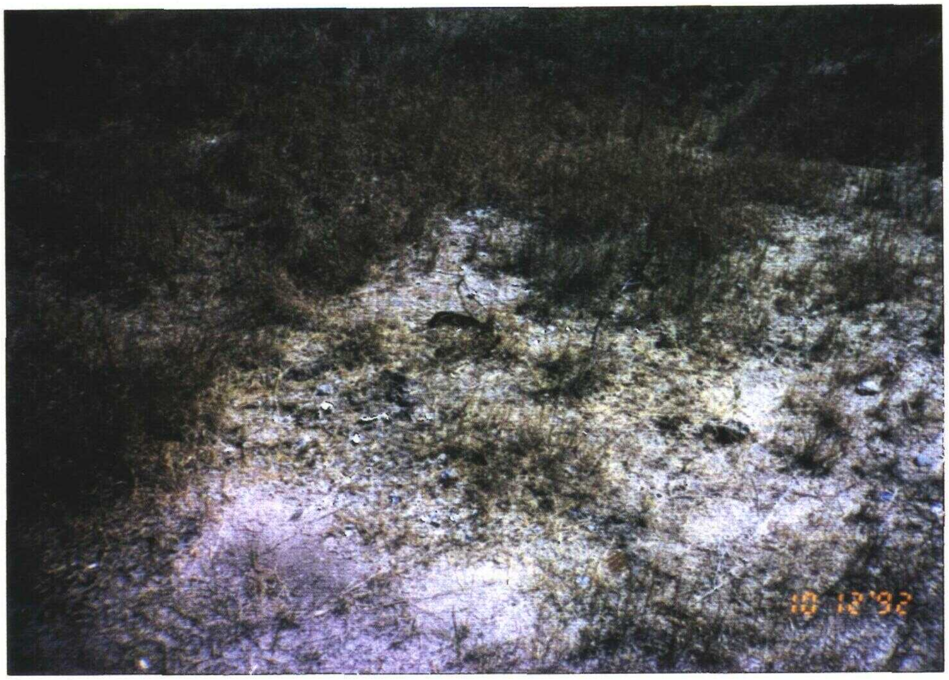


Photo 3 (10/12/92): Bare soil area with exposed materials in west central area of Area A, northeast of boat storage area, facing west (TXD 988051652)

Photo 4 (10/12/92): Bare soil area with exposed materials west of Windmill Lakes Blvd. in northeast corner of the west part of Area A, facing west (TXD 988051652)

Photo 5 (10/12/92): Bare soil area near the intersection of Windmill Lakes Blvd. and Windwater Road on the east side of Area A, facing south (TXD 988051652)

Photo 6 (10/12/92): Bare soil area with wire exposed along southern portion of the east side of Area A, facing south (TXD 988051652)

Photo 7 (10/12/92): Bare soil area with crystalline material exposed in the southwest corner of the east side of Area A, near apartments, facing northeast (TXD 988051652)

Photo 8 (10/12/92): Bare soil area on the east side of the boat storage area near Monitoring Well 10; view from Windmill Lakes Blvd., facing west (TXD 988051652)

Photo 9 (10/12/92): View of breached fence south of Windmill Lake at north side of the parking lot at the Beverly Hills Park, facing north (TXD 988051652)

Photo 10 (10/13/92): Collection of soil samples SO-4 and SO-6 (duplicate) adjacent to Monitoring Well 2, located between Lake Westwind and Area A, facing northwest (TXD 988051652)

Photo 11 (10/13/92): Collection of soil sample SO-8, upgradient along the PPE of Lake Westwind, facing south (TXD 988051652)

Photo 12 (10/13/92): Collection of soil sample SO-5, along the surface drainage pathway northwest of the boat storage area within the western portion of the closed landfill, Area A, facing northeast (TXD 988051652)

Photo 13 (10/13/92): Collection of soil sample SO-9, bare soil area east of the boat storage shed, in the vicinity of Monitoring Well 10; central cap area along the western side of Area A, facing south (TXD 988051652)

Photo 14 (10/13/92): Background soil sample location SO-3, north of Windwater Road, facing southeast (TXD 988051652)

Photo 15 (10/13/92): Collection of soil sample SO-1, bare soil area south of the intersection of Windmill Lakes Blvd. and Windwater Road on the east side of the landfill Area A, facing northwest (TXD 988051652)

Photo 16 (10/13/92): Collection of soil sample SO-2, marshy area along the east side of Windmill Lakes Blvd. in the approximate center of Area A, facing northwest (TXD 988051652)

Photo 17 (10/13/92): Collection of soil sample SO-7, in the southeast corner of Area A across the road from the horse stables, along the surface drainage ditch, facing south (TXD 988051652)

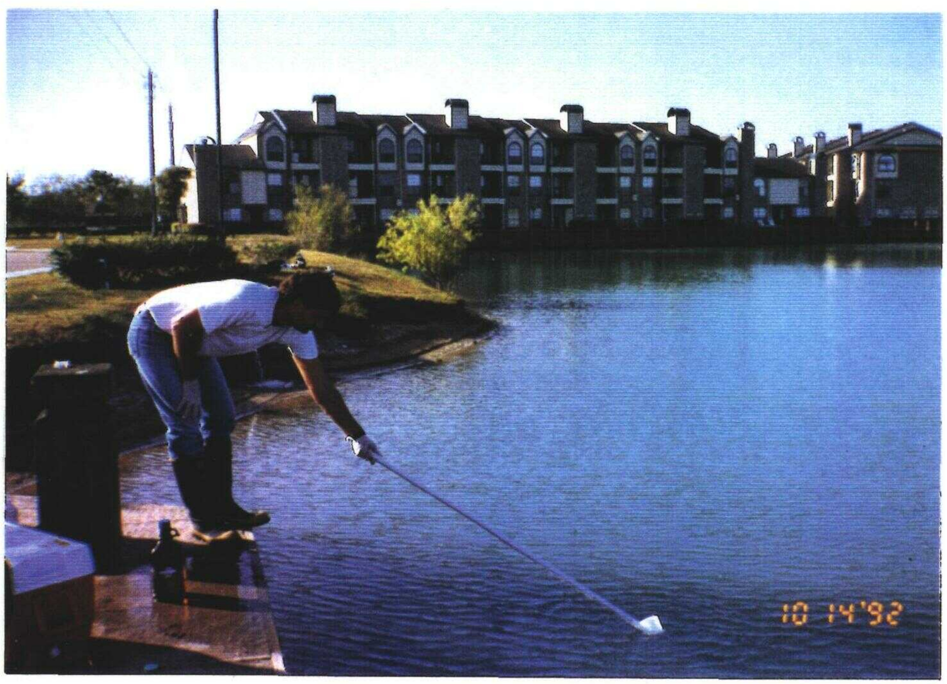


Photo 18 (10/14/92): Collection of surface water sample SW-3, from Bass Lake along pier, facing south (TXD 988051652)

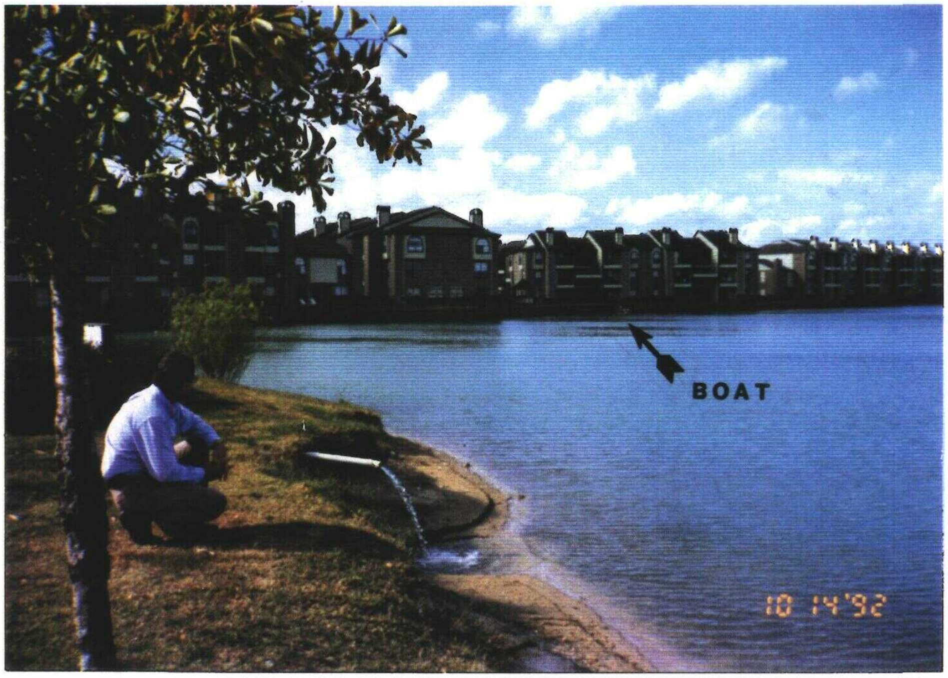


Photo 19 (10/14/92): Collection of first Bass Lake sediment sample, composite sample SE-3, from boat [see arrow], facing southwest (TXD 988051652)

Photo 20 (10/14/92): Collection of second Bass Lake sediment sample, composite sample SE-3, from boat [see arrow], facing west (TXD 988051652)

Photo 21 (10/14/92): Collection of surface water sample SW-1, taken from Windmill Lake, facing south (TXD 988051652)

Photo 23 (10/14/92): Collection of sediment samples SE-2 and SE-4 (duplicate) from Lake Westwind, facing northwest (TXD 988051652)

Photo 25 (10/14/92): Collection of surface water samples SW-2 and SW-5 (duplicate) from Lake Westwind, facing northwest (TXD 988051652)

Photo 27 (10/14/92): Collection of sample GW-5 from Monitoring Well 2, located between Lake Westwind Collection of sample SO-2 from nonvegetated area in southeast corner of lot, facing northwest (TXD 988051652)

Photo 28 (10/14/92): Sample location Monitoring Well 8, located in apartment complex south of Area A and north of Windmill Lake, facing northwest (TXD 988051652)

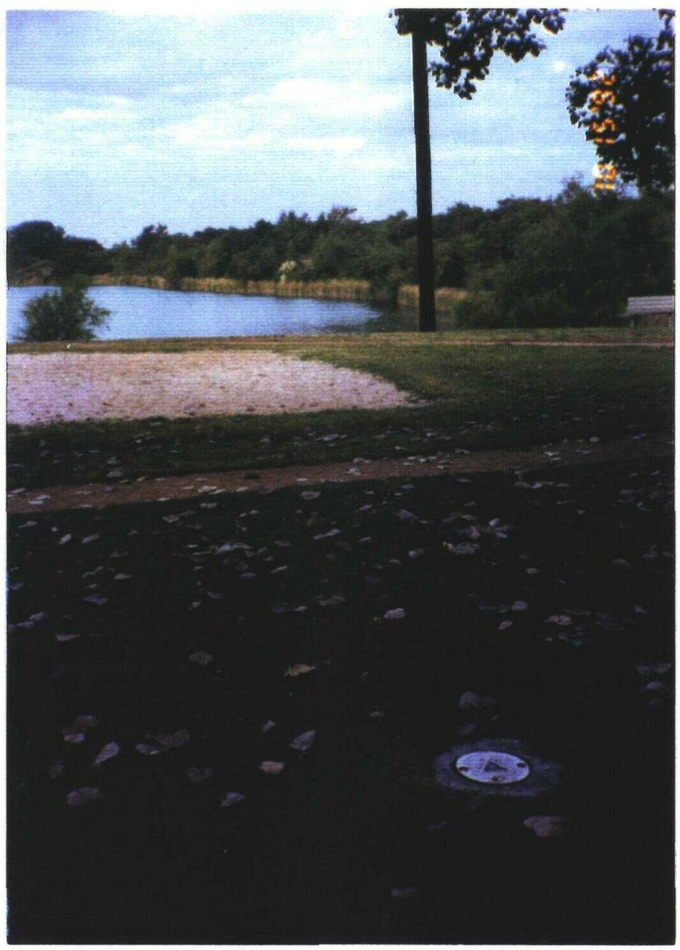


Photo 29 (10/15/92): Monitoring Well location MW-1, sample GW-8, Lake Westwind in background, facing west (TXD 988051652)

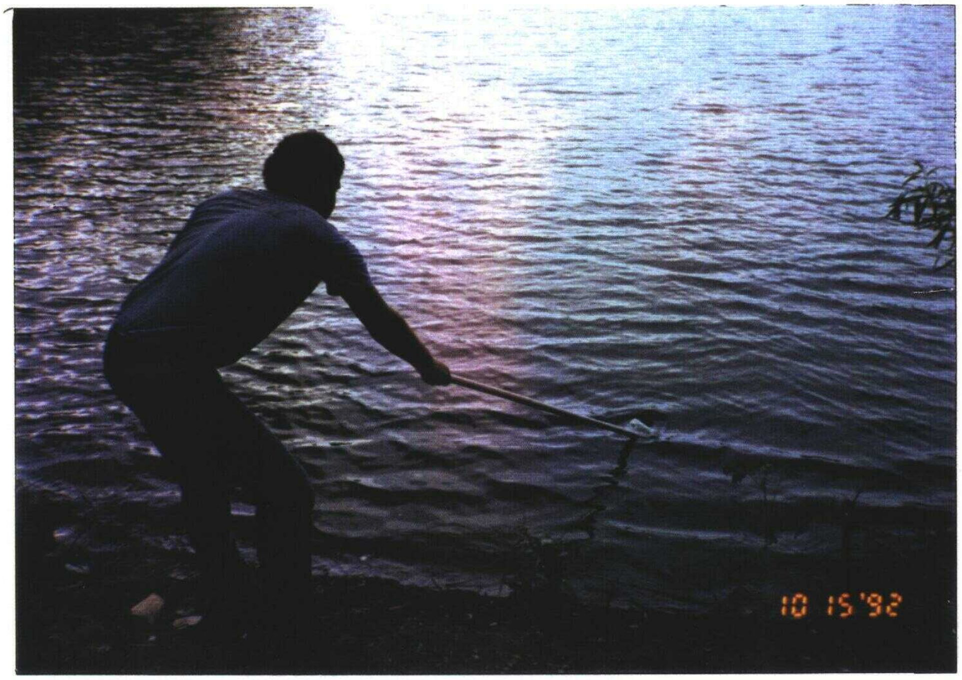


Photo 30 (10/15/92): Collection of sample SW-4, taken from north edge of the 4th lake, the lake adjacent to Windmill Lake, facing south (TXD 988051652)

Photo 31 (10/15/92): Verifying landfill cap thickness in bare soil area east of boat storage, facing northeast (TXD 988051652)

Photo 32 (10/15/92): Verifying landfill cap thickness in bare soil area northeast of boat storage area, facing southwest; strong gas odor noted (TXD 988051652)

Photo 33 (10/15/92): Close-up view of previous location, facing west (TXD 988051652)

Photo 34 (10/15/92): Verifying landfill cap thickness in bare soil just south of apartment complex on the west side of Windmill Lakes Blvd., facing north (TXD 988051652)

Photo 35 (10/15/92): Verifying landfill cap thickness in bare soil just east of Windmill lakes Blvd., approximately in the center of Area A, facing south (TXD 988051652)

Photo 36 (10/15/92): Verifying landfill cap thickness in bare soil area south and east of the intersection of Windmill Lakes Blvd. and Windwater Road, facing west (TXD 988051652)

Photo 37 (10/15/92): Collection of soil sample SO-10 obtained east and north of boat storage area, facing north; area has strong gas odors (TXD 988051652)

Photo 38 (10/15/92): Groundwater sample locations GW-1 and GW-9 (duplicate) taken from water well located at 9416 Lambright Road, facing west (TXD 988051652)

Photo 39 (10/15/92): Close-up view of previous location, facing west (TXD 988051652)

Photo 40 (10/15/92): Collection of groundwater sample GW-2, taken from the water well located at 9905 Radio Road, facing west (TXD 988051652)

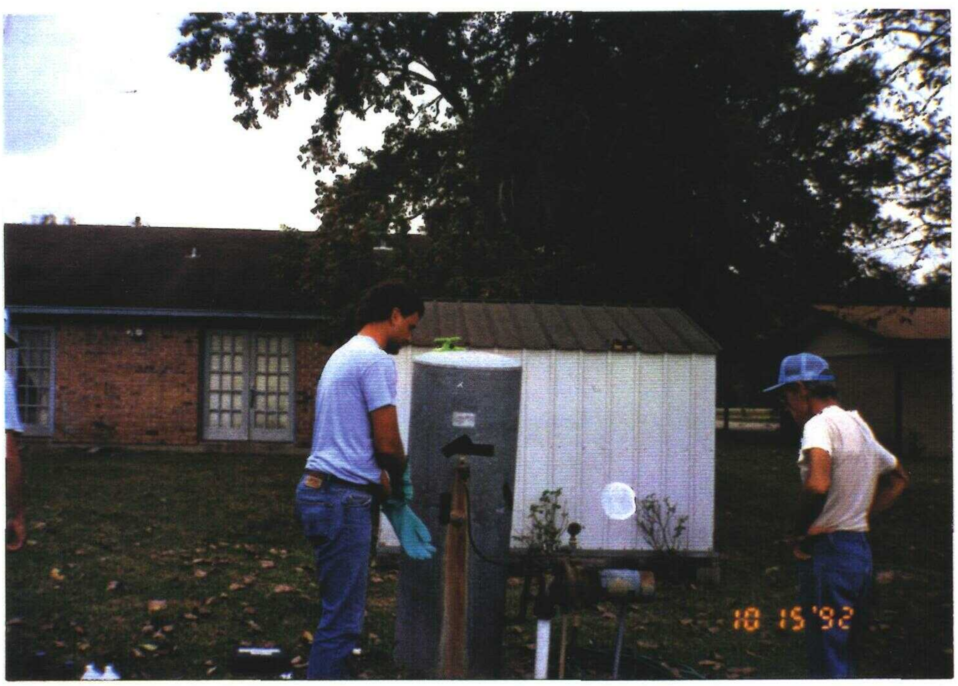


Photo 41 (10/15/92): Collection of groundwater sample GW-3, taken from the water well located at 9916 Radio Road, facing southeast (TXD 988051652)

Appendix B

Reference Material

Appendix B.1

Geology and Groundwater References

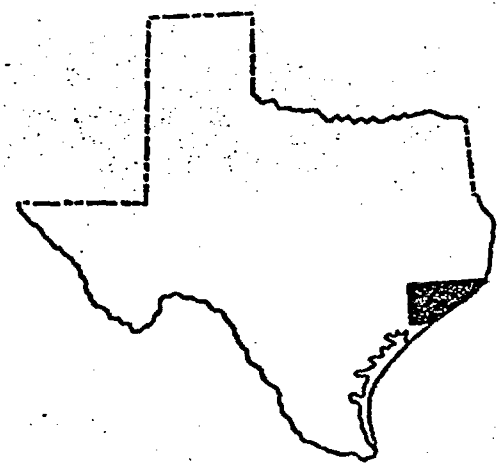
BUREAU OF ECONOMIC GEOLOGY
THE UNIVERSITY OF TEXAS AT AUSTIN
AUSTIN, TEXAS 78712

W. L. FISHER, *Director*

GEOLOGIC ATLAS OF TEXAS

Houston Sheet

Scale: 1:250,000



1982


North Houston
Paradise Oil Field
Houston North
Oil & Gas Field
Radio towers
Durkee Oil Field
Garden Park
Highland Heights
Little York
Aldine
Gulf Coast
Pumping station
San Jacinto Park
Magnolia Gardens
Sheldon Reservoir
Sheldon
Sacred Heart Cemetery
Barrett
Trinity Garden
Water tower
Highlands
Lynchburg
Beacon
Scott Bay
Baytown
Baytown Tunnel
HOUSTON
Substation
Water works
Galena Park
Pasadena
South Houston
Deer Park
La Porte
Atkinson Island
Sylvan Beach
Bayside Terra
Red Bluff
Pierce Junction
Radio tower
Lotus
Garden Villa
East Haven
Houston Service Center
Genoa
Bayou
HARRIS COUNTY
CHAMBERS CO
Obstructions
Todville
Seabrook
Oil Field
Kemah
Lakeside
League City
Oil Field
Windmill
Dickinson
Qb
Ql
Qal
Qd
Julia
Oil Field
Alvin
Arcadia
Hitchcock
Cem

Report 236

STRATIGRAPHIC AND HYDROGEOLOGIC FRAMEWORK OF PART OF THE COASTAL PLAIN OF TEXAS

TEXAS DEPARTMENT OF WATER RESOURCES

July 1979

Table 1.--Stratigraphic and Hydrogeologic Framework of Part of the Coastal Plain of Texas

Era	System	Series	Stratigraphic Units	Hydrogeologic Units	Selected Faunal Markers	Remarks
CENOZOIC	Quaternary	Holocene	Alluvium	Chicot aquifer		Quaternary System undifferentiated on sections.
		Pleistocene	Beaumont Clay			
			Montgomery Formation			
			Bentley Formation			
			Willis Sand			
	Tertiary	Pliocene	Goliad Sand	Evangeline aquifer		Goliad Sand overlapped east of Lavaca County.
		Miocene	Fleming Formation	Burkeville confining system	*Potamides matsoni* *Bigenerina nodosaria var. directa* *Bigenerina humblei* *Amphistegina sp.*	
			Oakville Sandstone	Jasper aquifer		Oakville Sandstone included in Fleming Formation east of Washington County.
			Surface: Catahoula Tuff or Sandstone; Subsurface: Upper part of Catahoula Tuff or Sandstone		*Discorbis nomada* *Discorbis gravelli* *Heterostegina sp.*	Catahoula Tuff designated as Catahoula Sandstone east of Lavaca County.
			Subsurface: Anahuac Formation	Catahoula confining system (restricted)	*Marginulina idiomorpha*	Anahuac and "Frio" Formations may be Oligocene in age.
			Subsurface: "Frio" Formation		*Textularia mississippiensis*	
		Oligocene(?)	Surface: Frio Clay; Subsurface: Vicksburg Group equivalent	Not discussed as hydrologic units in this report.	*Textularia warreni*	Frio Clay overlapped or not recognized on surface east of Live Oak County.
		Eocene	Jackson Group: Whitsett Formation: Fashing Clay Member			Indicated members of Whitsett Formation apply to south-central Texas. Whitsett Formation east of Karnes County may be, in part or in whole, Oligocene in age.
			Jackson Group: Whitsett Formation: Calliham Sandstone Member or Tordilla Sandstone Member			
			Jackson Group: Whitsett Formation: Dubose Member		*Marginulina cocoaensis*	
			Jackson Group: Whitsett Formation: Deweesville Sandstone Member			
			Jackson Group: Whitsett Formation: Conquista Clay Member		*Textularia hockleyensis*	
			Jackson Group: Whitsett Formation: Dilworth Sandstone Member		*Massilina pratti*	
			Jackson Group: Manning Clay			
			Jackson Group: Wellborn Sandstone		*Textularia dibollensis*	
			Jackson Group: Caddell Formation			
			Claiborne Group: Yegua Formation		*Nonionella cockfieldensis*	
			Claiborne Group: Cook Mountain Formation		*Discorbis yeguaensis*	
			Claiborne Group: Sparta Sand		*Eponides yeguaensis*	
			Claiborne Group: Weches Formation		*Ceratobulimina eximia*	
			Claiborne Group: Queen City Sand			
			Claiborne Group: Reklaw Formation			
			Claiborne Group: Carrizo Sand			
			Wilcox Group			
		Paleocene	Midway Group			

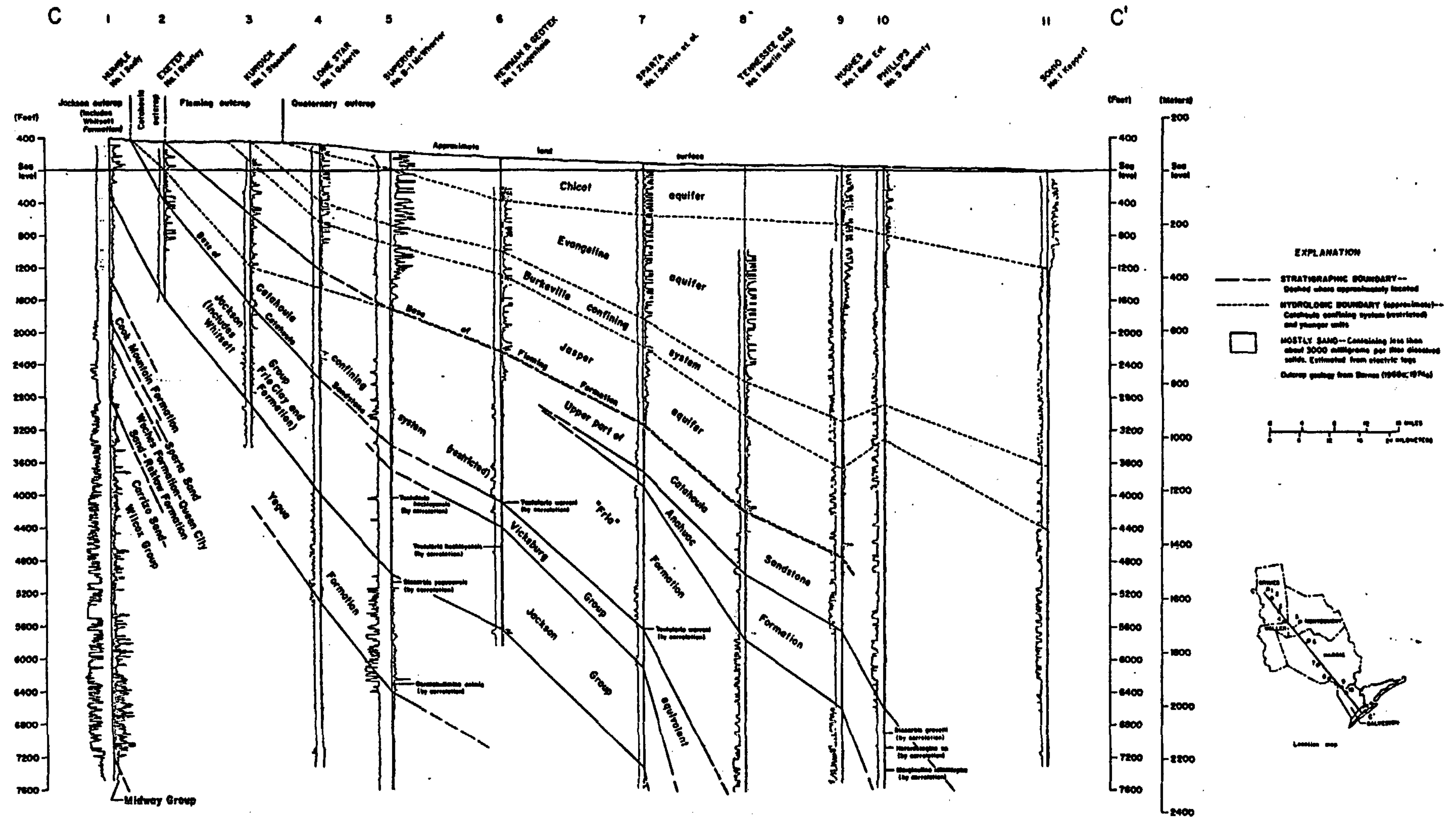


Figure 4
Stratigraphic and Hydrogeologic Section C-C'

subsurface correlations of the Catahoula-Fleming contact, as well as formation thicknesses, will continue to differ.

Burkeville Confining System

The Burkeville confining system, which was named by Wesselman (1967) for outcrops near the town of Burkeville in Newton County, Texas, is delineated on the sections from the Sabine River to near the Rio Grande. It separates the Jasper and Evangeline aquifers and serves to retard the interchange of water between the two aquifers.

The Burkeville has been mapped in this report as a rock-stratigraphic unit consisting predominantly of silt and clay. Boundaries were determined independently from time concepts although in some places the unit appears to possess approximately isochronous boundaries. In most places, however, this is not the case. For example, the entire thickness of sediment in the Burkeville confining system in some areas is younger than the entire thickness of sediment in the Burkeville in other places.

The configuration of the unit is highly irregular. Boundaries are not restricted to a single stratigraphic unit but transgress the Fleming-Oakville contact in many places. This is shown on sections D-D' to G-G' and J-J' (Figures 5-8 and 11). Where the Oakville Sandstone is present, the Burkeville crops out in the Fleming but dips gradually into the Oakville because of facies changes from sand to clay downdip.

The typical thickness of the Burkeville ranges from about 300 to 500 feet (91 to 152 m). However, thick sections of predominantly clay in Jackson and Calhoun Counties account for the Burkeville's gradual increase to its maximum thickness of more than 2,000 feet (610 m) as shown on section F-F' (Figure 7).

The Burkeville confining system should not be construed as a rock unit that is composed entirely of silt and clay. This is not typical of the unit, although examples of a predominance of silt and clay can be seen in some logs in sections H-H' and I-I' (Figures 9-10). In most places, the Burkeville is composed of many individual sand layers, which contain fresh to slightly saline water; but because of its relatively large percentage of silt and clay when compared to the underlying Jasper aquifer and overlying Evangeline, the Burkeville functions as a confining unit.

Evangeline Aquifer

The Evangeline aquifer, which was named and defined by Jones (Jones, Turcan, and Skibitzke, 1954) for a ground-water reservoir in southwestern Louisiana, has been mapped also in Texas, but heretofore has been delineated no farther west than Washington, Austin, Fort Bend, and Brazoria Counties. Its presence as an aquifer and its hydrologic boundaries to the west have been a matter of speculation. D. G. Jorgensen, W. R. Meyer, and W. H. Sandeen of the U.S. Geological Survey (written commun., March 1, 1976) recently refined the delineation of the aquifer in previously mapped areas and continued its delineation to the Rio Grande. The boundaries of the Evangeline as they appear on the sections in this report are their determinations.

The Evangeline aquifer has been delineated in this report essentially as a rock-stratigraphic unit. Although the aquifer is composed of at least the Goliad Sand, the lower boundary transgresses time lines to include sections of sand in the Fleming Formation. The base of the Goliad Sand at the outcrop coincides with the base of the Evangeline only in South Texas as shown in sections H-H' to K-K' (Figures 9-12). Elsewhere, the Evangeline at the surface includes about half of the Fleming outcrop. The upper boundary of the Evangeline probably follows closely the top of the Goliad Sand where present, although this relationship is somewhat speculative.

The Evangeline aquifer is typically wedge shaped and has a high sand-clay ratio. Individual sand beds are characteristically tens of feet thick. Near the outcrop, the aquifer ranges in thickness from 400 to 1,000 feet (122 to 305 m), but near the coastline, where the top of the aquifer is about 1,000 feet (305 m) deep, its thickness averages about 2,000 feet (610 m). The Evangeline is noted for its abundance of good quality ground water and is considered one of the most prolific aquifers in the Texas Coastal Plain. Fresh to slightly saline water in the aquifer, however, is shown to extend to the coastline only in section J-J' (Figure 11).

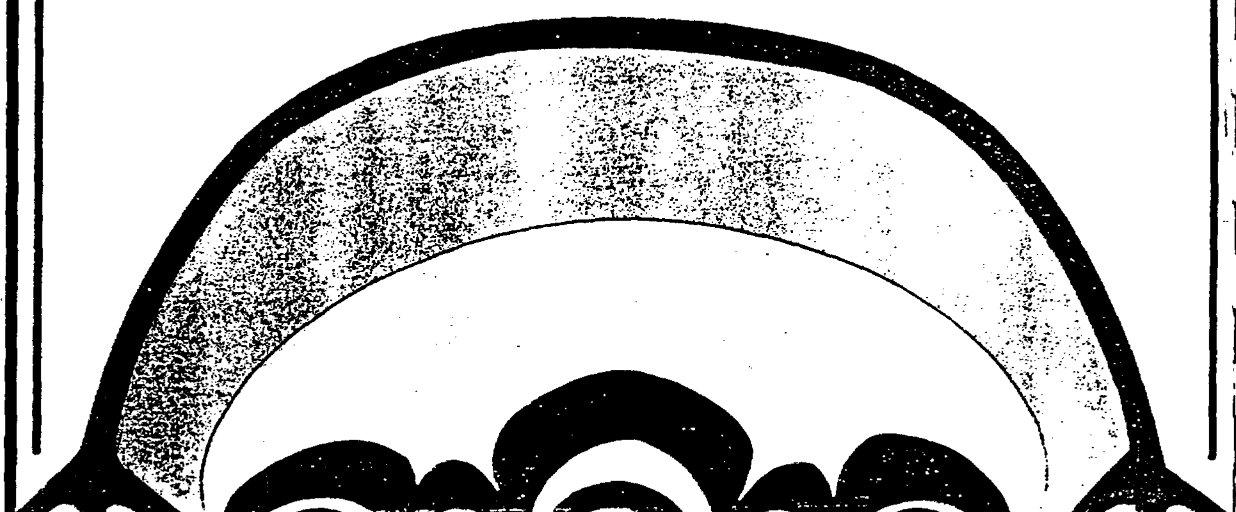
Chicot Aquifer

The Chicot aquifer, which was named and defined by Jones (Jones, Turcan, and Skibitzke, 1954) for a ground-water reservoir in southwestern Louisiana, is the youngest aquifer in the Coastal Plain of Texas. Over the years, the aquifer gradually was mapped westward from Louisiana into Texas where, heretofore, its most westerly mapped limit was Austin, Fort Bend, and Brazoria Counties. In this report, the delineation of the Chicot was refined in previously mapped areas and extended to near the Rio Grande by D. G. Jorgensen, W. R. Meyer, and W. M. Sandeen of the U.S. Geological Survey (written commun., March 1, 1976).

It is believed that the base of the Chicot in some areas has been delineated on the sections in this report as the base of the Pleistocene. Early work in Southeast Texas indicates that the Chicot probably comprises the Willis Sand, Bentley Formation, Montgomery Formation, and Beaumont Clay of Pleistocene age and any overlying Holocene alluvium (Table 1). The problem that arises in this regard is that the base of the Pleistocene is difficult to pick from electrical logs. Thus any delineation of the base of the Chicot in the subsurface as the base of the Pleistocene is automatically suspect. At the surface, the base of the Chicot on the sections has been picked at the most landward edge of the oldest undissected coastwise terrace of Quaternary age. In practice, the delineation of the Chicot in the subsurface, at least on the sections in Southeast Texas, has been based on the presence of a higher sand-clay ratio in the Chicot than in the underlying Evangeline. In some places, a prominent clay layer was used as the boundary. Differences in hydraulic conductivity or water levels in some areas also served to differentiate the Chicot from the Evangeline.

The high percentage of sand in the Chicot in Southeast Texas, where the aquifer is noted for its abundance of water, diminishes southwestward. Southwest of section G-G' (Figure 8) the higher clay content of the Chicot and the absence of fresh to slightly saline water in the unit is sharply contrasted with the underlying Evangeline aquifer that still retains relatively large amounts of sand and good quality water.

GROUNDWATER



R. Allan Freeze/John A. Cherry

CHAPTER 9

Groundwater Contamination

the air) during sample preparation and during the tests. Since the adsorptive capabilities of oxidized materials can be much different than reduced materials, the test results can be invalid for analysis of contaminant behavior in field systems.

The most direct but rarely the most convenient method for determining the partitioning and retardation of the contaminant is to conduct field tests. Injection of a solution of appropriate composition into a small segment of the groundwater system followed by monitoring of its behavior can provide, in favorable circumstances, a basis for prediction of contaminant behavior elsewhere in the system. Field tests of this type can be time-consuming and expensive. In order to obtain adequate information, numerous tests may be required. In some situations the need to obtain reliable information on contaminant behavior is great enough to justify this effort.

Another approach for obtaining information on the partitioning and retardation of contaminants during transport in groundwater is to conduct investigations at existing sites where groundwater pollution has already occurred. For results of these investigations to have more than site-specific significance, not only must the distributions of the contaminants in the water and on the porous media be determined, but the factors that influence these distributions must also be investigated. During recent years an appreciable number of detailed studies of sites with subsurface contamination have been reported in the literature. Some of the more notable examples are those by McKee et al. (1972), Childs et al. (1974), Suarez (1974), Ku et al. (1978), Goodall and Quigley (1977), and Gillham and Cherry (1978).

9.5 Sources of Contamination

Land Disposal of Solid Wastes

In North America approximately 3 kg of refuse per capita is produced daily. More than 20,000 landfills across the continent accommodate more than 90% of the solid waste that is produced by municipal and industrial activities. According to Yen and Scanlon (1975), a city of 1 million people generates refuse with an annual volume equivalent to 80 ha covered 5 m deep. Although materials recovery and incineration may eventually decrease the amount of waste that is disposed of by landfilling, landfills will continue to be the primary method of disposal of these wastes during at least the next few decades.

The design, construction, and operational aspects of land disposal of refuse are described by Mantell (1975). For purposes of this discussion this information is not required, other than to recognize that much of the solid waste (refuse) that is now disposed of on land is emplaced in engineered disposal systems known as *sanitary landfills*. In sanitary landfills, solid waste is reduced in volume by compaction and then is covered with earth. Ideally, the earth cover is placed over the refuse at the conclusion of each day's operation, but in practice less frequent cover application is common. The landfill, consisting of successive layers of compacted waste and earth, may be constructed on the ground surface or in excavations. In North America a large number of the older sites that receive municipal wastes are open dumps or poorly operated landfills. Newer sites are generally better situated and better operated. It is estimated that 90% of the industrial wastes that are considered to be hazardous are landfilled, primarily because it is the least expensive waste management option.

Our purpose here is to consider some of the effects that refuse disposal can have on the groundwater environment. With the exception of arid areas, buried refuse in sanitary landfills and dumps is subject to leaching by percolating water derived from rain or snowmelt. The liquid that is derived from this process is known as *leachate*. Table 9.4 indicates that leachate contains large numbers of inorganic contaminants and that the total dissolved solids can be very high. Leachate also contains many organic contaminants. For example, Robertson et al. (1974) identified more than 40 organic compounds in leachate-contaminated groundwater in a sandy aquifer in Oklahoma. These authors concluded that many of these compounds were produced by leaching of plastics and other discarded manufactured items within the refuse. Not only do the leachates emanating from

Table 9.4 Representative Ranges for Various Inorganic Constituents in Leachate From Sanitary Landfills

Parameter	Representative range (mg/ℓ)
K^+	200–1000
Na^+	200–1200
Ca^{2+}	100–3000
Mg^+	100–1500
Cl^-	300–3000
SO_4^{2-}	10–1000
Alkalinity	500–10,000
Fe (total)	1–1000
Mn	0.01–100
Cu	<10
Ni	0.01–1
Zn	0.1–100
Pb	<5
Hg	<0.2
NO_3^-	0.1–10
NH_4^+	10–1000
P as PO_4	1–100
Organic nitrogen	10–1000
Total dissolved organic carbon	200–30,000
COD (chemical oxidation demand)	1000–90,000
Total dissolved solids	5000–40,000
pH	4–8

SOURCES: Griffin et al., 1976; Leckie et al., 1975.

landfills contain contaminants derived from solids, but many leachates contain toxic constituents from liquid industrial wastes placed in the landfill.

Concern has developed in recent years with regard to the effect of landfills on the quality of groundwater resources. Garland and Mosher (1975) cite several examples where groundwater pollution has been caused by landfills. A case where leachate migration caused serious pollution of a large aquifer used as a city's water supply is described by Apgar and Satherthwaite (1975). It is expected that the cost of rectifying this situation will eventually total many millions of dollars.

Numerous investigations in North America and Europe have shown that in nonarid regions, infiltration of water through refuse causes water table mounding within or below the landfill. The mounding process is similar to that described in Section 8.11. Water-table mounding causes leachate to flow downward and outward from the landfill as illustrated in Figure 9.24. Downward flow of leachate may threaten groundwater resources. Outward flow normally causes leachate springs at the periphery of the landfill or seepage into streams or other surface-water bodies. If the paths of leachate migration do not lead to aquifers containing potable water, downward movement of leachate will not pose a threat to groundwater resources.

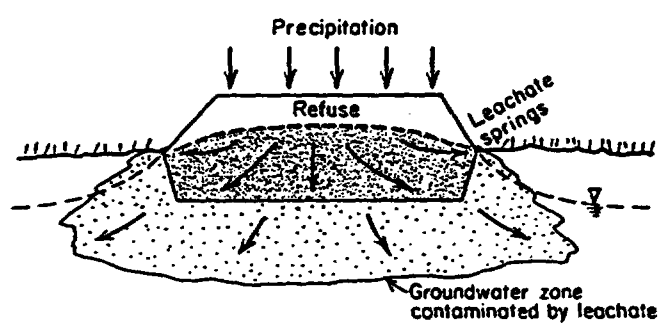


Figure 9.24 Water-table mound beneath a landfill, causing leachate springs and migration of contaminants deeper into the groundwater zone.

In situations where landfills are located in relatively permeable materials such as sand, gravel, or fractured rock, leachate migration may cause contamination over areas many times larger than the areas occupied by the landfills. An example of such a case is shown in Figure 9.25. At this landfill site on moderately permeable glaciodeltaic sand, a large plume of leachate-contaminated water, represented in Figure 9.25 by the Cl^- distribution, has penetrated deep into the aquifer and has moved laterally several hundreds of meters along the paths of groundwater flow. This contamination developed over a period of 35 years. Infiltration of water through the landfill will continue to produce leachate for many decades. Transport by groundwater flow in the sand will cause the zone of contamination to greatly expand. In this particular case, however, the aquifer is not

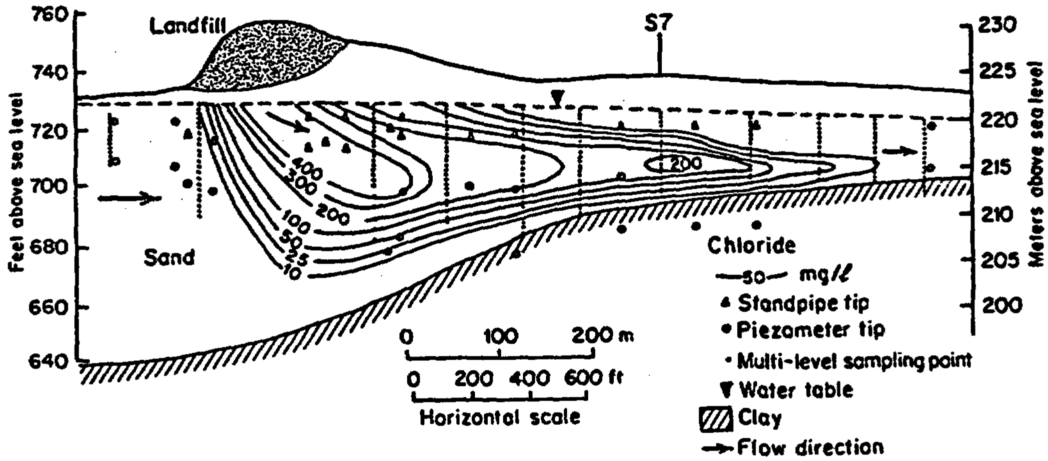


Figure 9.25 *Plume of leachate migrating from a sanitary landfill on a sandy aquifer; contaminated zone is represented by contours of Cl^- concentration in groundwater.*

used for water supply. The spreading contaminant plume is therefore not regarded as a significant problem. At a landfill on sand and gravel on Long Island, N.Y., Kimmel and Braids (1974) delineated a leachate plume that is more than 3000 m long and greater than 50 m in depth. These two examples and others described in the literature indicate that if leachate has access to active groundwater flow regimes, pollution can spread over very large subsurface zones. Physical and chemical processes are sometimes incapable of causing appreciable attenuation of many of the toxic substances contained within the leachate plume.

If landfills are situated in appropriate hydrogeologic settings, both groundwater and surface-water pollution can be avoided. It is commonly not possible, however, to choose sites with ideal hydrogeologic characteristics. In many regions land of this type is not available within acceptable transportation distances, or it may not be situated in an area that is publicly acceptable for land filling. For these and other reasons most landfills are located on terrain that has at least some unfavorable hydrogeologic features.

Although it is well established that landfills in nonarid regions produce leachate during at least the first few decades of their existence, little is known about the capabilities for leachate production over much longer periods of time. In some cases leachate production may continue for many decades or even hundreds of years. It has been observed, for example, that some landfills from the days of the Roman Empire are still producing leachate. Many investigators have concluded that at the present time there have been very few occurrences of leachate contamination of aquifers that are used for water supply. Whether or not it will be possible to draw similar conclusions many years from now remains to be established.

Farvolden and Hughes (1976) have concluded that solid waste can be buried at almost any site without creating an undue groundwater pollution hazard, provided that the site is properly designed and operated. A testing program to define the hydrogeological environment is essential. These authors indicate that if uncontrolled leachate migration is unacceptable, the leachate should be collected and treated as a liquid waste. One feasible way to ensure that no leachate leaves the site is to establish a hydraulic gradient toward the site, perhaps by pumping. Liners for emplacement beneath landfills are currently being evaluated as a control method but have not yet been established in practice. Some examples of controls on leachate migration using drains or wells are shown in Figure 9.26. These types of control measures require that the collected leachate be treated or otherwise managed in an appropriate manner.

In addition to the production of leachate, infiltration of water into refuse causes gases to be generated as biochemical decomposition of organic matter

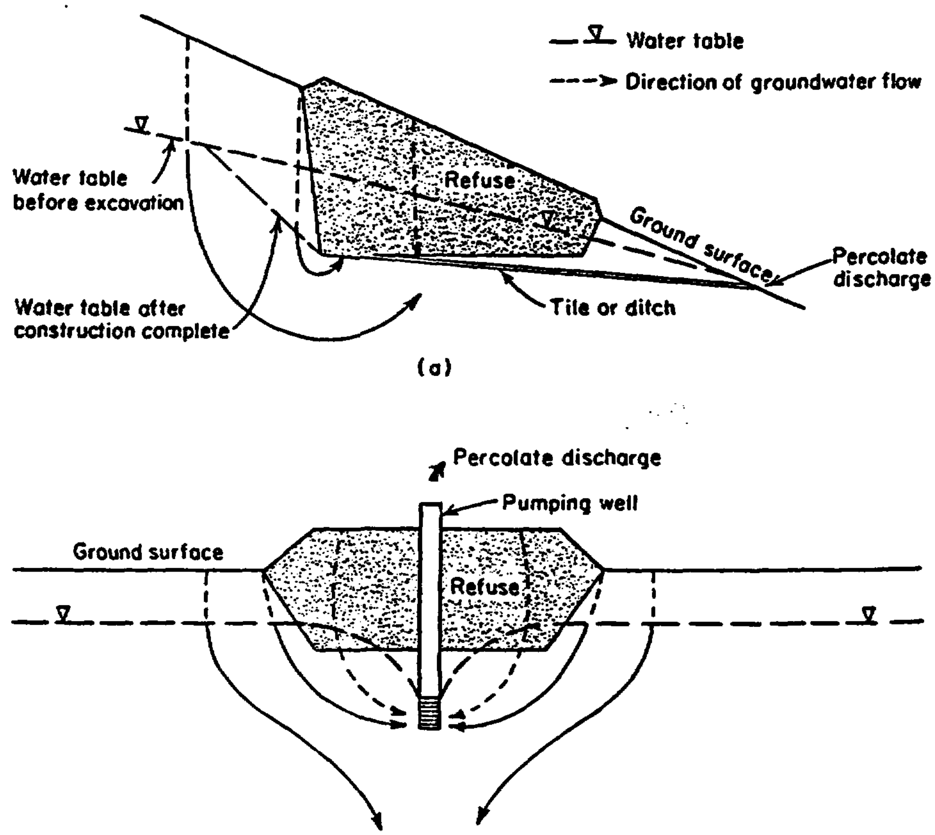


Figure 9.26 Control of leachate in a sanitary landfill by (a) tile drain or ditch and (b) pumped well (after Hughes et al., 1971).

occurs. Gases such as CO_2, CH_4, H_2S, H_2, and N_2 are commonly observed. CO_2 and CH_4 are almost invariably the most abundant of these gases. CH_4 (methane) has a low solubility in water, is odorless, and generally is of little influence on groundwater quality. In the environmental impact of landfills, however, it can be of great importance because of its occurrence in gaseous form in the zone above the water table. It is not uncommon for CH_4 to attain explosive levels in the refuse air. In some situations CH_4 at dangerous levels can move by gaseous diffusion from the landfill through the unsaturated zone in adjacent terrain. Migration of CH_4 at combustible levels from landfills through soils into residences has occurred in urban areas. In recent years, installation of gas vents in landfills to prevent buildup of methane in the zone above the water table has become a common practice.

In addition to hazards caused by the potential for methane explosion, gaseous migration from landfills can result in extensive damage to vegetation and odor problems. Case histories of gas migration from landfills have been described by Flower (1976). Mohsen (1975) has presented a theoretical analysis of subsurface gas migration from landfill sources. The interactions of the various factors that influence gas production in landfills have been described by Farquhar and Rovers (1973).

Sewage Disposal on Land

Sewage is placed on or below the land surface in a variety of ways. Widespread use of septic tanks and drains in rural, recreational, and suburban areas contributes filtered sewage effluent directly to the ground. Septic tanks and cesspools are the largest of all contributors of wastewater to the ground and are the most frequently reported sources of groundwater contamination in the United States (U.S. Environmental Protection Agency, 1977). Twenty-nine percent of the U.S. population disposes of its domestic waste through residential disposal systems. An increasing percentage of the municipal sewage in industrialized countries is being processed in primary and secondary sewage treatment plants. Although this decreases surface-water pollution, it produces large volumes of solid residual materials known as *sewage sludge*. In many areas this sludge, which contains a large number of potential contaminants, is spread on agricultural or forested lands. In some regions liquid sewage that has not been treated or that has undergone partial treatment is sprayed on the land surface. Application of liquid sewage and sewage sludge to the land provides nutrients such as nitrogen, phosphorus, and heavy metals to the soil. This can stimulate growth of grasses, trees, and agricultural crops. Land that is infertile can be made fertile by this practice. One of the potential negative impacts of this type of sewage disposal is degradation of groundwater quality.

Primary- and secondary-treated sewage is being spread on forested land and crop land in an increasing number of areas in Europe and North America. For example, in Muskegon County, Michigan, more than 130 million liters per day of sewage effluent is sprayed on the land surface (Bauer, 1974). For many decades cities such as Berlin, Paris, Milan, Melbourne, Fresno, and many others have been using sewage for irrigation of crops. Not only are the nutrients in sewage effluent valuable, but the water itself is a valuable resource in many regions. In some situations intensely treated sewage effluent may be used as a source of artificial recharge for aquifers that serve for municipal water supply. Injection of treated sewage into coastal aquifers may serve as a means of controlling the intrusion of salt water.

Considering the many ways in which liquid and solid constituents from sewage reach the land surface and subsurface zones, it is reasonable to expect that over the long term the quality of groundwater resources in many areas will reflect the extent to which hydrogeologic factors are considered in the overall planning and operation of sewage management systems. In a textbook of this type it is not feasible to look specifically at the hydrogeologic and geochemical factors that are important in each of the land-application or disposal-of-sewage options that are in use. Before proceeding to other topics, however, we will provide a brief guide to some of the more important studies that have been conducted. For a detailed guide to the literature in this area, the reader is referred to the U.S. Environmental Protection Agency (1974a).

During the 1950's and early 1960's it was observed that one of the most serious consequences of land disposal of sewage by way of septic systems was contamination of groundwater by alkyl benzene sulfonate (ABS), which was a major component of household detergents. ABS is relatively nonbiodegradable and exists in water in anionic form. In the 1960's, numerous cases of shallow contamination of sand and gravel aquifers were reported. The problem was most acute in areas where septic systems were draining into unconfined aquifers in which there were numerous shallow water supply wells. Case histories of this type of problem in Long Island and in Southern California are described by Perlmutter et al. (1964) and Klein (1964).

In the mid-1960's the detergent industry replaced ABS with linear alykl sulfonate (LAS), a compound that is readily biodegradable in aerobic environments. Cases of LAS and ABS contamination of wells have been a rare occurrence since LAS gained widespread use, a somewhat surprising situation considering that many septic systems drain into anaerobic groundwater environments where the effects of biodegradation are probably minimal. LAS may undergo considerable retardation as a result of adsorption.

Effluent from septic systems includes many other types of contaminants. One of the most frequently reported of these contaminants in groundwater is nitrate. As indicated in Section 9.3, nitrate commonly does not undergo complete biochemical reduction to N_2 even if the groundwater system is anaerobic. Nitrate emanating from septic systems into groundwater is transported along the groundwater flow paths. A detailed case history of the migration of nitrate and other contaminants in groundwater as a result of discharge from septic systems was presented by Childs et al. (1974).

In some areas the primary concern with regard to contaminant migration from septic systems is surface-water quality rather than groundwater quality.

This is particularly the case in areas of recreational lakes where cottages and tourist facilities use septic systems located near lakes. Transport of nitrogen and phosphorus through the groundwater zone into lakes can cause lake eutrophication manifested by accelerated growth of algae and decrease in water clarity. Some examples of hydrogeologic investigations in recreational lake environments are described by Dudley and Stephenson (1973) and Lee (1976).

Another concern associated with the disposal of treated or untreated sewage on or below the land surface revolves around the question of how far and how fast pathogenic bacteria and viruses can move in subsurface flow systems. This problem is also crucial in the development of municipal water supplies by extraction of water from wells located adjacent to polluted rivers. The literature is replete with investigations of movement of bacteria through soils or granular geological materials. As bacteria are transported by water flowing through porous media, they are removed by straining (filtering), die-off, and adsorption. The migration of the bacterial front is greatly retarded relative to the velocity of the flowing water. Although bacteria can live in an adsorbed state or in clusters that clog parts of the porous medium, their lives are generally short compared to groundwater flow velocities. In medium-grained sand or finer materials, pathogenic and coliform organisms generally do not penetrate more than several meters (Krone et al., 1958). Field studies have shown, however, that in heterogeneous aquifers of sand or gravel, sewage-derived bacteria can be transported tens or hundreds of meters along the groundwater flow paths (Krone et al., 1957; Wesner and Baier, 1970).

Viruses are very small organic particles (0.07–0.7 μm in diameter) that have surface charge. There is considerable evidence from laboratory investigations indicating that viruses are relatively immobile in granular geological materials (Drewry and Eliassen, 1968; Robeck, 1969; Gerba et al., 1975; Lance et al., 1977). Adsorption is a more important retardation mechanism than filtering in highly permeable granular deposits. Problems associated with sampling and identification of viruses in groundwater systems have restricted the understanding of virus behavior under field conditions. Advances in sampling technology (Wallis et al., 1972; Sweet and Ellender, 1972) may lead to a greatly improved understanding of virus behavior in aquifers recharged with sewage effluent.

Although there is considerable evidence indicating that bacteria and viruses from sewage have small penetration distances when transported by groundwater through granular geologic materials, similar generalizations cannot be made for transport in fractured rock. It is known that these microorganisms can live for many days or even months below the water table. In fractured rocks, where groundwater velocities can be high, this is sufficient time to produce transport distances of many kilometers.

As man relies more heavily on land application as a means of disposal for municipal sewage effluent and sludge, perhaps the greatest concern with regard to groundwater contamination will be the mobility of dissolved organic matter. Sewage effluent contains many hundreds of dissolved organic compounds, of which very little is known about their toxicity and mobility. Some of these compounds may eventually be shown to be more significant in terms of degradation of groundwater quality than nitrate, trace metals, bacteria, or viruses.

Agricultural Activities

Of all the activities of man that influence the quality of groundwater, agriculture is probably the most important. Among the main agricultural activities that can cause degradation of groundwater quality are the usage of fertilizers and pesticides and the storage or disposal of livestock or fowl wastes on land. The most widespread effects result from the use of fertilizer. In industrialized countries most fertilizer is manufactured chemically. This type of fertilizer is known as inorganic fertilizer. In less developed countries, animal or human wastes are widely used as organic fertilizer.

Fertilizers are categorized with respect to their content of nitrogen (N), phosphorus (P), and potassium (K). These are the three main nutrients required by crops. The annual application rates of fertilizers vary greatly from region to region and from crop to crop. Nitrogen applications, (expressed as N), generally vary from about 100 to 500 kg/ha·yr. Because fertilizer is used year after year, it is to be expected that in many areas some of the N, P, or K is carried by infiltrating water downward to the water table, where it can migrate in the groundwater flow regime. For reasons explained in Section 9.3, nitrogen in the form of NO_3^- is generally much more mobile in subsurface flow systems than dissolved species of phosphorus. Cation exchange causes K^+ to have low mobility in most nonfractured geologic materials.

Of the three main nutrients in fertilizer, N in the form of NO_3^- is the one that most commonly causes contamination of groundwater beneath agricultural lands. High NO_3^- concentrations have been delineated in extensive areas in many parts of the world, including Israel (Saliternik, 1972), England (Foster and Crease, 1972), Germany (Groba and Hahn, 1972), California (Calif. Bureau Sanitary Eng., 1963; Nightingale, 1970; Ayers and Branson, 1973), Nebraska (Spalding et al., 1978), southern Ontario, and southern Alberta. Many wells in these areas have NO_3^- concentrations that exceed the recommended limit for drinking water. In areas where NO_3^- contamination is areally extensive, fertilizer rather than animal wastes from feedlots or lagoons or septic field seepage is usually identified as the primary nitrogen source. Nitrate is the principal dissolved nitrogen component, with ammonium and organic nitrogen present in much lower concentrations. Although in many aquifers that are contaminated by NO_3^-, the concentrations are below the limits recommended for drinking water, it is disturbing to note that gradual increases in NO_3^- have been observed. The widespread use of inorganic fertilizers began after World War II. The major impact on groundwater quality resulting from this change in agricultural practice is probably not yet fully developed. Nitrate contamination is rarely reported at depths of more than about 10–100 m below the water table. As time goes on, however, NO_3^- contamination may extend to greater depth in areas where there are significant downward flow components. For example, NO_3^- in deep wells in California, ranging in depth from 240 to 400 m below ground surface, increased from approximately 1 mg/ℓ in 1950 to 10–17 mg/ℓ in 1962 (Broadbent, 1971). The extent to which denitrification occurs as water moves along regional flow paths is a major uncertainty inherent in predictions of long-term NO_3^- increases in aquifers.

In England, NO_3^- contamination of a large regional carbonate-rock aquifer is widespread. Analysis of the occurrence and movement of NO_3^- in this aquifer is complicated by the fact that NO_3^- is carried in groundwater flowing in a network of joints and solution channels, while some of the NO_3^- is lost from the active flow regime as a result of diffusion into the porous matrix of the limestone (Young et al., 1977). If at some time in the future the NO_3^- concentration in the flow network declines, NO_3^- will diffuse from the matrix back into the flow regime.

Although extensive NO_3^- contamination of shallow groundwater can often be attributed to leaching of fertilizer, NO_3^- in shallow groundwater in large areas in southern Alberta (Grisak, 1975), southern Saskatchewan, Montana (Custer, 1976), and Texas (Kreitler and Jones, 1975) is not caused by fertilizer use. In these areas it appears that most of the NO_3^- is derived by oxidation and leaching of natural organic nitrogen in the soil. The greater abundance and deeper penetration of oxygen into the soil has occurred as a result of cultivation. In some areas the initial turning of the sod as settlers moved on the land was probably a major factor. In other areas continual deep cultivation during the modern era of farming has been a major influence.

In many agricultural areas shallow groundwater has become contaminated locally as a result of leaching of NO_3^- from livestock and fowl wastes. The conversion of organic nitrogen in these wastes to NO_3^- takes place through biochemical processes. Relatively small source areas such as farm manure piles, fowl-waste lagoons, and feedlots contribute NO_3^- to groundwater, but if these contaminant sources are not directly underlain by aquifers, the contamination is rarely very significant. Specific cases of groundwater contamination from animal wastes are reported by Hedlin (1972) and by Gillham and Webber (1969). In agricultural areas contamination of shallow wells by NO_3^- and other consituents commonly occurs because of faulty well construction. If wells are not properly sealed by grout or clay along the well bore above the screen, contaminated runoff can easily make its way to the aquifer zone near the well screen.

Concurrent with the widespread increase in the use of chemical fertilizers since World War II has been the rapid development and use of a multitude of organic pesticides and herbicides. In a report on groundwater pollution in the southwestern United States, Fuhriman and Barton (1971) concluded that pollution by pesticides must be listed as an important potential hazard. However, they obtained no direct evidence indicating significant pesticide contamination of groundwater. Kaufman (1974), in a review of the status of groundwater contamination in the United States, indicates that this conclusion appears to characterize today's situation—that of a potential but as-yet-unrealized problem. Based on a literature review and field studies in Kent, England, Croll (1972) arrived at a similar conclusion. It is well known from laboratory experiments that many

Appendix B.2

Meteorological Data

U.S. DEPARTMENT OF COMMERCE
LUTHER H. HODGES, Secretary

WEATHER BUREAU
F. W. REICHELDERFER, Chief

TECHNICAL PAPER NO. 40

RAINFALL FREQUENCY ATLAS OF THE UNITED STATES

for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years

Prepared by
DAVID M. HERSHFIELD
Cooperative Studies Section, Hydrologic Services Division
for
Engineering Division, Soil Conservation Service
U.S. Department of Agriculture

THIS ATLAS IS OBSOLETE FOR THE FOLLOWING 11 WESTERN STA

VOL.	STATE	GPO STOCK NO.	PR
I	MONTANA	0317-00155	$ 8
II	WYOMING	0317-00156	8
III	COLORADO	0317-00157	10
IV	NEW MEXICO	0317-00158	8
V	IDAHO	0317-00159	8.
VI	UTAH	0317-00160	10.
VII	NEVADA	0317-00161	8.
VIII	ARIZONA	0317-00162	8.
IX	WASHINGTON	0317-00163	8.
X	OREGON	0317-00164	8.
XI	CALIFORNIA	0317-00165	10.

THE ABOVE: NOAA ATLAS 2 VOLUMES ARE AVAILABLE FOR COST INDICATED FROM THE SUPERINTENDENT OF DOCUMEN GOVERNMENT PRINTING OFFICE, WASHINGTON, D.C. 20402.

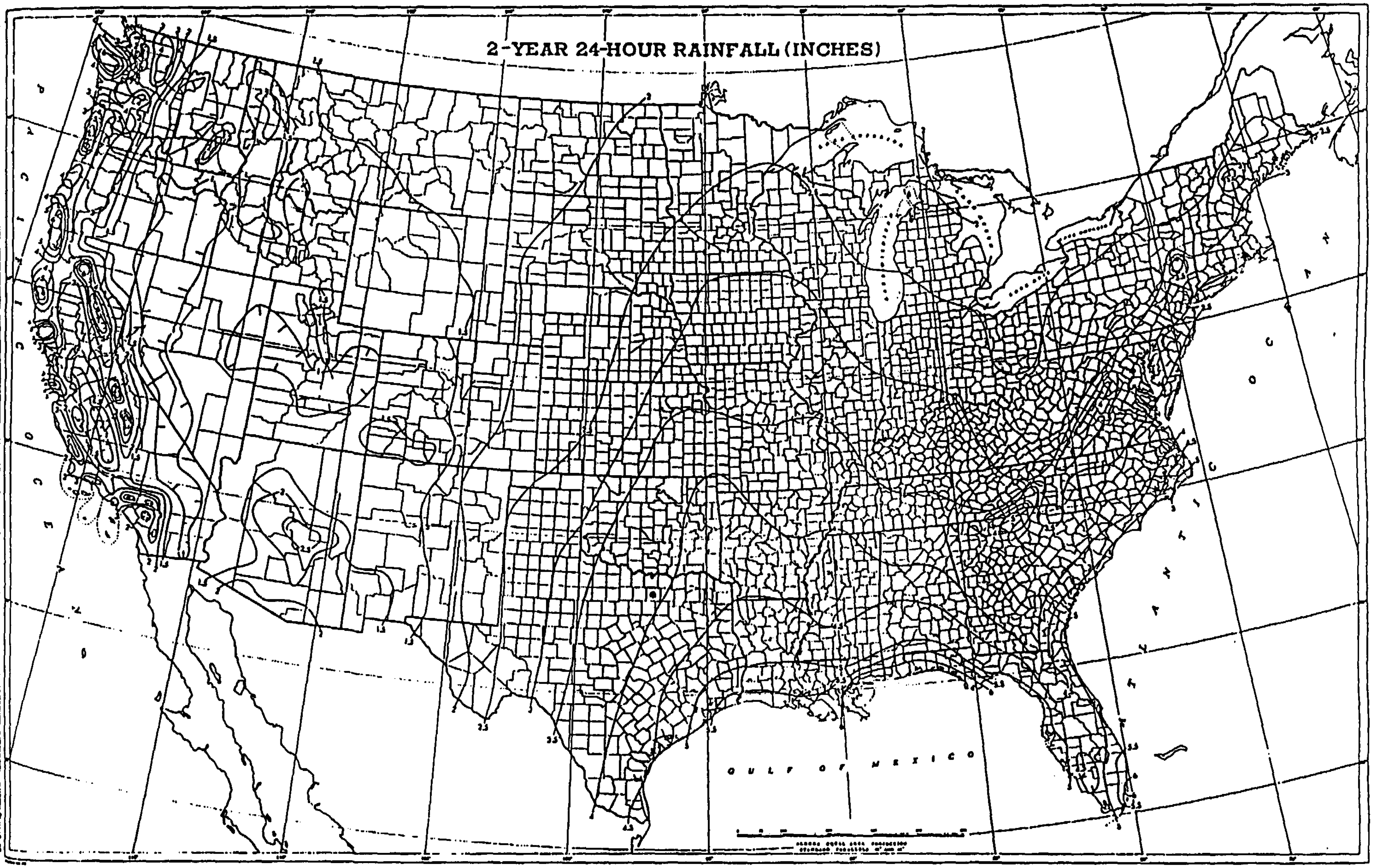
NOTICE
Rainfall-frequency information for durations of 1 hour and less for the Central and Eastern States has been superseded by NOAA Technical Memorandum NWS HYDRO-35 Five to Sixty-Minute Precipitation Frequency for the Eastern and Central United States. This publication (Accession No. PB 272-112/AS) is obtainable from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161

The cost is $4.50 per copy ($3 for the microfiche version).

WASHINGTON, D.C.
May 1961

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.


2-YEAR 24-HOUR RAINFALL (INCHES)
GULF OF MEXICO

Houston Facts

1991 - 1992

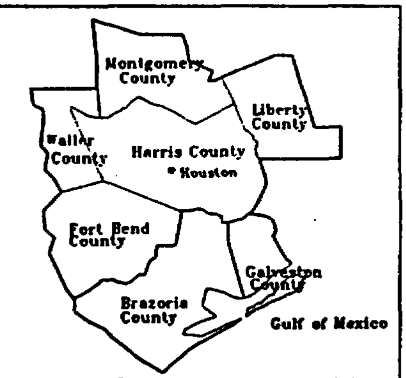
A publication of the Greater Houston Partnership's Research Department $3

Geography

LOCATION: Houston, seat of Harris County, Texas, is located on the upper Gulf Coast prairies at 95°22' West and 29°46' North, 50 miles from the Gulf of Mexico. Official altitude of the City of Houston is 49'; Harris County ranges from sea level to 310'.

AREA: The *Houston-Galveston-Brazoria Consolidated Metropolitan Statistical Area* (CMSA) consists of three Primary Metropolitan Statistical Areas (PMSAs): the *Houston PMSA* (Fort Bend, Harris, Liberty, Montgomery, and Waller Counties), the *Galveston-Texas City PMSA* (Galveston County), and the *Brazoria PMSA* (Brazoria County). For convenience, the longer titles are shortened to "Houston CMSA" and "Galveston PMSA" in *Houston Facts*.

Houston CMSA	7,422.38	sq.mi.
Houston PMSA	5,435.48	sq.mi.
Harris County	1,776.81	sq.mi.
City of Houston	581.44	sq.mi.
Brazoria PMSA	1,486.80	sq.mi.
Galveston PMSA	500.10	sq.mi.



Houston-Galveston-Brazoria CMSA

The City of Houston lies in three counties: Harris (567.31 sq.mi.), Fort Bend (12.06 sq.mi.), and Montgomery (2.07 sq.mi.). Harris County contains part or all of 32 incorporated areas.

Under Texas' Municipal Annexation Act of 1963, cities have certain powers over surrounding unincorporated areas, termed the Extraterritorial Jurisdiction. ETJ is a function of population; for cities over 100,000, it can cover all unincorporated area within five miles of any point on the city limits. Houston's ETJ contains about 1,800 sq.mi.

Weather

TEMPERATURE: Houston averages 21.8 dates per year with low temperatures of 32°F or less and 93.9 dates with high temperatures of 90°F or more; temperatures rarely reach 100°F. Houston's growing season averages 300 days; the normal frostfree period extends from Feb. 14 to Dec. 11. *Normal daily maximum:* winter 67°F, summer 92°F, spring and autumn 79°F. *Normal daily minimum:* winter 45°F, summer 71°F, spring and autumn 57°F. *Record extremes:* 108°F in 1909, 5°F in 1930.

Based on departure from 65°F, Houston averages 1,549 heating degree days and 2,761 cooling degree days per year.

PRECIPITATION: Annual average: 44.76". Thunderstorms occur, on average, 62 dates per year. *Record monthly extremes:* 16.28" in Jun. 1989, 0.05" in Oct. 1978. Highest daily total: 10.80" in Nov. 1943. Houston has had 13 measurable snowfalls since 1939.

Annual average relative humidity: midnight 86%, 6 a.m. 90%, noon 59%, 6 p.m. 65%.

SUNSHINE: Houston averages 56% of possible sunshine annually, ranging from 43% in January to 66% in July.

WEATHER DATA 1990*

	Average Temperature °F	Diff. from Normal °F	Total Precipitation In.	Diff. from Normal In.
Jan	57.0	5.6	3.96	0.75
Feb	59.1	4.6	4.54	1.29
Mar	62.9	1.9	5.11	2.43
Apr	69.4	0.7	6.21	1.97
May	78.1	3.2	2.23	-2.46
Jun	84.8	4.2	2.98	-1.08
Jul	82.1	-1.0	4.85	1.52
Aug	85.1	2.5	0.31	-3.35
Sep	80.1	1.7	1.57	-3.36
Oct	68.7	-1.0	3.79	0.12
Nov	63.4	3.3	3.01	-0.37
Dec	53.6	-0.4	1.81	-1.85
Year	*70.4*	*2.1*	*40.37*	*-4.39*

*Houston Intercontinental Airport

SUBJECT GUIDE

Data in Houston Facts 1991-1992 *are current as of March 31, 1991, unless otherwise noted. All information was compiled by the Research Department of the Greater Houston Partnership.*

Data followed by S&MM *in parentheses are copyrighted by* Sales & Marketing Management, *and are reproduced with permission.*

GREATER HOUSTON PARTNERSHIP
Chamber of Commerce Division
Economic Development Division
World Trade Division

Appendix B.3

Miscellaneous Communication

ES ENGINEERING-SCIENCE, INC.
HOUSTON

MEMORANDUM TO FILE

JOB NO. AU332.11
FILE DESIGNATION TUC SSI/MWC
DATE 12/10/92 TIME 4 15 PM

PHONE CALL FROM Carolyn Kelly, Associate Scientist PHONE NO. (713)943-5490
PHONE CALL TO Shannon Breslin, TX Parks and Wildlife PHONE NO. (512) 448-4311

CONFERENCE WITH

PLACE

SUBJECT Endangered Species at Mobile Waste Control Site

Shannon said that within a 4-mile radius of the site, 2 Federal Category 2 grasses are found:

Texas Windmill Grass
Houston Machaeranthera Grass

A snake on the Texas State Endangered Species list is possible in the area:

Smooth Green Snake

A toad on both the Federal and State lists has been in the area but not in large numbers since the '70s:

Houston Toad.

The area is considered a "disturbed" area because of development.

SIGNED Carolyn Kelly

ES ENGINEERING-SCIENCE COMPANIES

MEMORANDUM TO FILE

JOB NO. AU332.11

FILE DESIGNATION TUCSSI / Mobile Waste Controls

DATE 8/28/92 TIME 2:45pm

PHONE CALL FROM Joyce Bailey, Engineering-Science, Inc. PHONE NO. 713/943-5719

PHONE CALL TO Evelyn Gutierrez, Texas Air Control Brd, Austin, TX PHONE NO. 512/451-5711

CONFERENCE WITH

PLACE

SUBJECT TACB Records re: Mobile Waste Controls

None.

JBailey

cc: Kelly Kress

SIGNED

ES ENGINEERING-SCIENCE COMPANIES

MEMORANDUM TO FILE

JOB NO. AU332.11

FILE DESIGNATION TNC SSI / Mobile Waste Controls

DATE 8/28/92 TIME 10:00 am

PHONE CALL FROM PHONE NO.

PHONE CALL TO PHONE NO.

CONFERENCE WITH Phil Naugle (Inspector) & Frank Simon (Records Clerk), Texas

PLACE Air Control Board, District 7, Bellaire, Texas / Joyce Bailey, Engineering-Science, Inc. (@ TACB)

SUBJECT Files / Complaints re: Mobile Waste Controls

Based on review of accounts looking for

- Mobile Waste Controls
- NCNB
- FDIC
- Amer...
- Jones & Neuse

there are no files / records at TACB Dist 7 for the subject site.

Joyce

SIGNED

ES ENGINEERING-SCIENCE COMPANIES

MEMORANDUM TO FILE

JOB NO. AU332.11

FILE DESIGNATION TWC SSI / Mobile Waste Controls

DATE 8/28/92 TIME 2:27pm

PHONE CALL FROM Gene New, City of Houston, Bureau of Air Quality Control PHONE NO. 713/640-4200

RETURN PHONE CALL TO Joyce Bailey, Engineering-Science, Inc. PHONE NO. 713/943-5719

CONFERENCE WITH

PLACE

SUBJECT Complaints / Files / Records on Mobile Waste Controls

None per Mr. New.

Joyce

cc Kelley Krenek

SIGNED

ES ENGINEERING-SCIENCE COMPANIES

MEMORANDUM TO FILE

JOB NO. AU 332.11

FILE DESIGNATION

DATE 8/27/92 TIME 1:30

PHONE CALL FROM Kelly Krenz PHONE NO.

PHONE CALL TO NL & P PHONE NO.

CONFERENCE WITH

PLACE

SUBJECT Well No. 1202

The address of this well is 4500 Shaver.

SIGNED Kelly Krenz

ES ENGINEERING-SCIENCE COMPANIES

MEMORANDUM TO FILE

JOB NO. AU 332.11

FILE DESIGNATION

DATE 8/28/92 TIME 3:30 pm

PHONE CALL FROM Kelly Krenz PHONE NO.

PHONE CALL TO Marty Sanderlin PHONE NO. 457-5191

CONFERENCE WITH

PLACE

SUBJECT Mobile Waste Controls Site

The TWC and the City of Houston collected water samples only from the lake 2/20/92.

Analytical evidence collected by the TWC does not indicate environmental contamination in drinking water wells located along Radio Rd. approximately 1-mile west of the site.

MW-2 was not sampled by the TWC in December, 1991.

SIGNED Kelly Krenz

ES ENGINEERING-SCIENCE COMPANIES

MEMORANDUM TO FILE

JOB NO. AU.332.11

FILE DESIGNATION

DATE 8/27/92 TIME

PHONE CALL FROM PHONE NO.

PHONE CALL TO Geraldo Uria, Keystone Labs PHONE NO. 266-6800

CONFERENCE WITH

PLACE

SUBJECT Mobile Waste Controls Analytical Data

Samples taken from the lake sediments were analyzed twice according to internal lab QC procedures. Cause of anomalous results - matrix interference problems.

SBLK - QA/QC samples; laboratory grade water NOT SPIKED, analyzed for semi-volatile const.

VBLK - QA/QC samples; laboratory grade water NOT SPIKED, analyzed for volatile constituents.

SIGNED Kelly Kresz

Kif 2

ES ENGINEERING-SCIENCE COMPANIES

MEMORANDUM TO FILE

page 1 of 2

JOB NO. AU 332.11

FILE DESIGNATION

DATE 8/19/92 TIME 9.15-10:30

PHONE CALL FROM PHONE NO.

PHONE CALL TO PHONE NO.

CONFERENCE WITH Marty Sanderlin, TWC 457-5191

PLACE TWC District 7 offices

SUBJECT Mobile Waste Controls Site

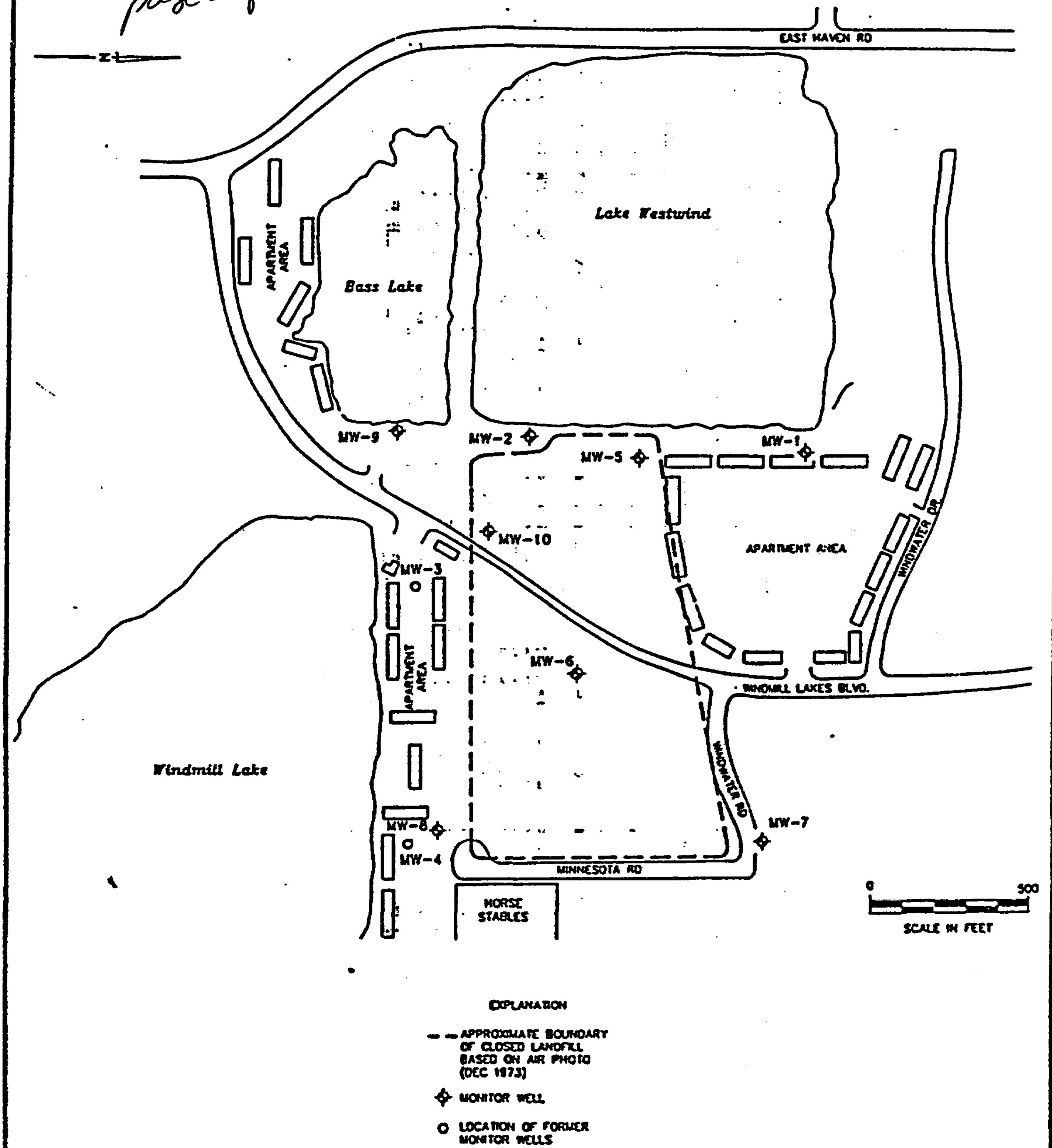
Discussion concerned Mobile Waste Controls site activities.

- landfill operations were discussed
- sampling conducted by the TWC, the City of Houston and the FDIC was discussed
- analytical results from the TWC & the City of Houston were provided for review
- a draft site map was provided
- a discussion was initiated about the citizens' complaint that was filed by Mrs. Betty Mitchell
- assistance was offered, as needed

SIGNED Kelly Frenz

DRAFT

page 2 of 2



NAME			Enviroplex	FILE No.
FOR	SCALE	MADE BY: DATE: CHECKED BY: DATE:		FIGURE

Ref 3

ES ENGINEERING-SCIENCE COMPANIES

MEMORANDUM TO FILE

JOB NO. AU 332.11

FILE DESIGNATION

DATE 8/31/92 TIME 11:00 AM

PHONE CALL FROM Kelly Krenz PHONE NO.

PHONE CALL TO Tom Gremlin, Amerisco Management PHONE NO. 214-508-44__ 214-508-5004

CONFERENCE WITH

PLACE

SUBJECT Windmill Landing/Mobile Waste Controls Site

The FDIC owns the 121.9-acre property that includes the landfill area but excludes the apartments, lakes, retail areas and roadways & common areas. It was foreclosed on in 1988 and acquired by the FDIC on 11/30/91. Debbie Gomez, Brown & Caldwell, Denver Co 303-750-3983 would be environmental site contact.

This commercial property is managed by Amerisco Management.

SIGNED Kelly Krenz

Appendix B.4

Surface Water Data for Segment 1102

 AV332.1(

NAME: Clear Creek Above Tidal

DESCRIPTION: from a point 100 meters (110 yards) upstream of FM 528 in Galveston/Harris County to Rouen Road in Fort Bend County

SEGMENT CLASSIFICATION: Water Quality Limited

LENGTH: 44 miles (71 kilometers)

DESIGNATED WATER USES: Contact Recreation
High Quality Aquatic Habitat

MONITORING STATIONS: 1102.0100, 1102.0200

INTENSIVE SURVEYS:	16 Sep 1976	Q,X,D,F,C,S,P,I,B	IMS-62	(Shaw: Sep 1977)
	10 Sep 1979	Q,X,D,R,F,C,B	IS-5	(Kirkpatrick: Jan 1980)

PERMITTED FACILITIES (FINAL):

Domestic	23 outfalls	30.35 MGD
Industrial	8 outfalls	0.09 MGD
Total	31 outfalls	30.44 MGD

KNOWN WATER PROBLEMS/WATER QUALITY STANDARD COMPARISON:

Dissolved oxygen levels are occasionally below 5.0 mg/L. This segment does not meet swimmable criteria due to frequently elevated levels of fecal coliform bacteria.

POTENTIAL WATER QUALITY PROBLEMS:

Supersaturated dissolved oxygen levels occur occasionally, and chlorides, total dissolved solids and fecal coliforms are rarely elevated. Inorganic nitrogen is frequently elevated, and total and orthophosphorus levels are persistently elevated.

RELATIVE SIGNIFICANCE OF POINT AND NONPOINT SOURCE POLLUTANTS:

Point source waste loads measurably affect water quality in this segment.

CONTROL PROGRAMS:

A. Existing: The Clear Lake Rule 31 (TAC Sections 333.1-333.3), adopted in March, 1981, imposes a treatment level (30-day average) of 5 mg/L BOD_5, 12 mg/L TSS, and 2 mg/L NH_3-N on all domestic sewage treatment plant discharges. Comparable effluent limitations are also required for industrial discharges.

B. Programs still to be implemented: None in the immediate future.

FACTORS NEEDING CLARIFICATION WITH RESPECT TO CAUSE/EFFECT RELATIONSHIPS:

None at this time.

KNOWN RELATIONSHIPS TO OTHER ENVIRONMENTAL PROBLEMS:

Affects water quality of Clear Creek tidal (Segment 1101) and Clear Lake (Segment 2425).

-The State of Texas Water Quality Inventory, 10th ed 1990, TWC, LP 90-06

NAME: Clear Creek Tidal

DESCRIPTION: from the confluence with Clear Lake in Galveston/Harris County to a point 100 meters (110 yards) upstream of FM 528 in Galveston/Harris County

SEGMENT CLASSIFICATION: Water Quality Limited

LENGTH: 14 miles (22 kilometers)

DESIGNATED WATER USES: Contact Recreation
High Quality Aquatic Habitat

MONITORING STATIONS: 1101.0050, 1101.0100, 1101.0150

INTENSIVE SURVEYS:	16 Sep 1976	Q,X,D,F,C,S,P,I,B	IMS-62	(Shaw: Sep 1977)
	10 Sep 1979	Q,X,D,R,F,C,B	IS-5	(Kirkpatrick: Jan 1980)

PERMITTED FACILITIES (FINAL):

Domestic	9 outfalls	18.23 MGD
Industrial	0 outfalls	0.00 MGD
Total	9 outfalls	18.23 MGD

KNOWN WATER QUALITY PROBLEMS/WATER QUALITY STANDARD COMPARISON:

Dissolved oxygen levels are occasionally below 4.0 mg/L. This segment does not meet swimmable criteria due to elevated fecal coliform bacteria in half the samples.

POTENTIAL WATER QUALITY PROBLEMS:

Total and orthophosphorus levels are persistently elevated, and inorganic nitrogen is frequently elevated. Chlorophyll a is periodically elevated.

RELATIVE SIGNIFICANCE OF POINT AND NONPOINT SOURCE POLLUTANTS:

Point source discharges measurably affect water quality in this segment.

CONTROL PROGRAMS:

A. Existing: The Clear Lake Rule (31 TAC Sections 333.1-333.3), adopted in March, 1981, imposes a treatment level (30-day average) of 5 mg/L BOD_5, 12 mg/L TSS, and 2 mg/L NH_3-N on all domestic sewage treatment plant discharges. Comparable effluent limitations are also required for industrial discharges.

B. Programs to be implemented: None in the immediate future.

FACTORS NEEDING CLARIFICATION WITH RESPECT TO CAUSE/EFFECT RELATIONSHIPS:

None at this time.

KNOWN RELATIONSHIPS TO OTHER ENVIRONMENTAL PROBLEMS:

Affects water quality of Clear Lake (Segment 2425).

WATER QUALITY STATUS:

THE FOLLOWING TABLE ILLUSTRATES THE LAST FOUR YEARS (OCT. 1, 1985 THRU SEPT. 30, 1989) OF WATER QUALITY INFORMATION FOR SEGMENT 1101.

PARAMETER	CRITERIA	NUMBER SAMPLES	MINIMUM	MAXIMUM	MEAN	NUMBER OF VALUES OUTSIDE CRITERIA	MEAN VALUES OUTSIDE CRITERIA
DISSOLVED OXYGEN (MG/L)	4.0	30	1	12.0	6.8	4	3.3
TEMPERATURE (F)	95.0	30	55.4	90.8	72.5	0	0
PH	6.5-9.0	24	7.2	8.7	7.9	0	0
CHLORIDE (MG/L)	N/A	29	108	12200	2344	0	0
SULFATE (MG/L)	N/A	27	31	1320	276	0	0
TOTAL DISSOLVED SOLIDS (MG/L)	N/A	24	405	15425	4318	0	0
FECAL COLIFORMS (#/100 ML)	200	26	10	13000	244	13	887

TOTAL DISSOLVED SOLIDS WERE ESTIMATED BY MULTIPLYING SPECIFIC CONDUCTANCE BY .50

Segment 2425 of the Bays and Estuaries

NAME: Clear Lake

DESCRIPTION:

SEGMENT CLASSIFICATION: Water Quality Limited

SURFACE AREA: 2.0 square miles (5.2 square kilometers)

DESIGNATED WATER USES: Contact Recreation
High Quality Aquatic Habitat

MONITORING STATIONS: 2425.0100, 2425.0120, 2425.0140, 2425.0200

INTENSIVE SURVEYS: 19 Feb 1980 F,C,A,Q,L (Kirkpatrick: unpublished)

PERMITTED FACILITIES (FINAL):

Domestic	3 outfalls	0.89 MGD
Industrial	11 outfalls	0.05 MGD
Total	14 outfalls	0.94 MGD

KNOWN WATER QUALITY PROBLEMS/WATER QUALITY STANDARD COMPARISON:

This segment has exhibited eutrophication-related problems; supersaturated dissolved oxygen levels occur occasionally.

POTENTIAL WATER QUALITY PROBLEMS:

Dissolved oxygen was depressed on one occasion. Total and orthophosphorus levels are persistently elevated. Fecal coliform bacteria exceed 200/100 mL in about one quarter of the samples. Inorganic nitrogen and chlorophyll *a* are periodically elevated.

RELATIVE SIGNIFICANCE OF POINT AND NONPOINT SOURCE POLLUTANTS:

Point and nonpoint source loads to the segment significantly affect water quality.

CONTROL PROGRAMS:

A. Existing: The Clear Lake Rule imposes a treatment level (30-day average) of 5 mg/L BOD_5, 12 mg/L TSS, and 2 mg/L NH_3-N on all domestic sewage treatment plant discharges. Comparable effluent limitations are also required for industrial discharges.

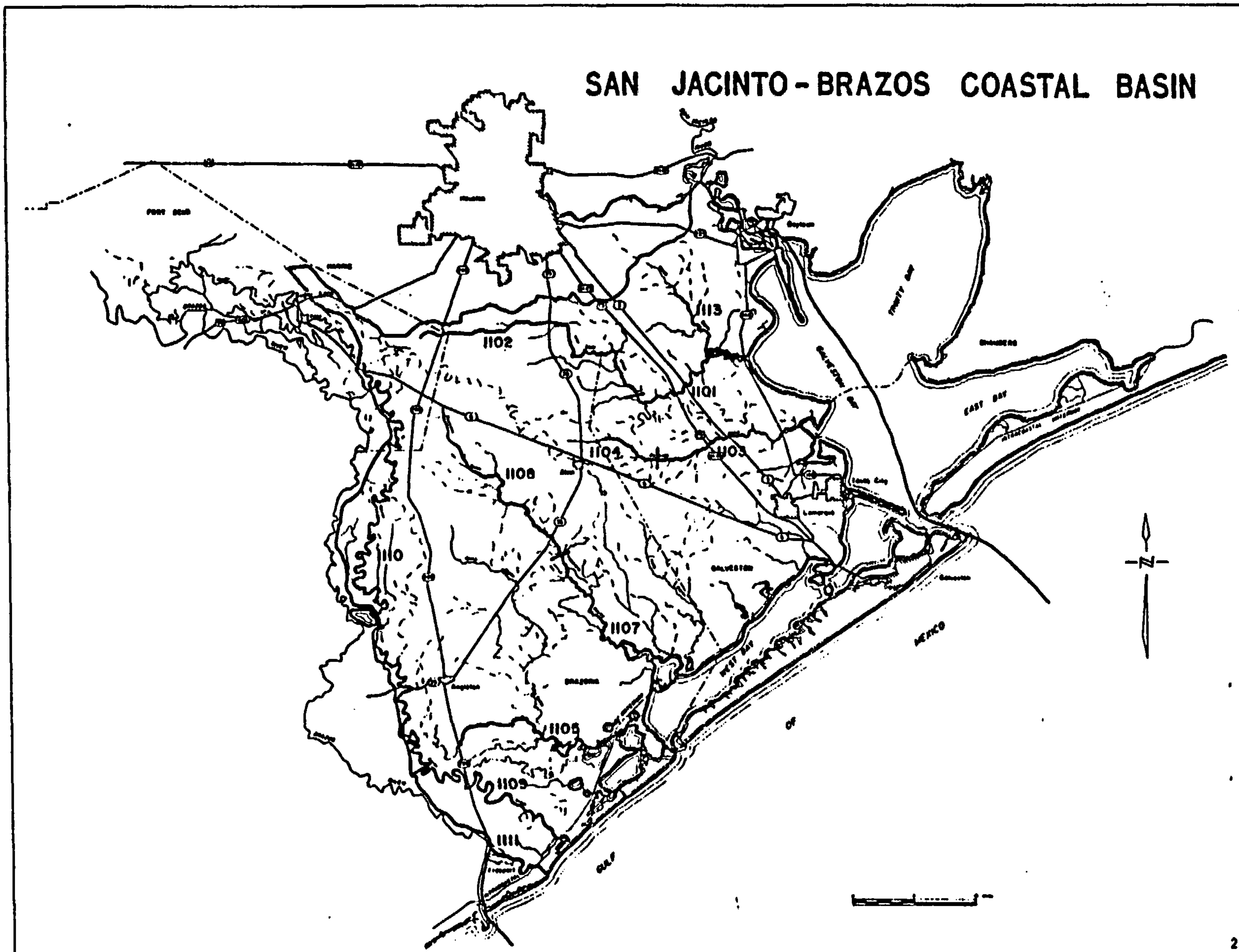
B. Programs still to be implemented: None in the immediate future.

FACTORS NEEDING CLARIFICATION WITH RESPECT TO CAUSE/EFFECT RELATIONSHIPS:

None at this time.

KNOWN RELATIONSHIPS TO OTHER ENVIRONMENTAL PROBLEMS:

None.



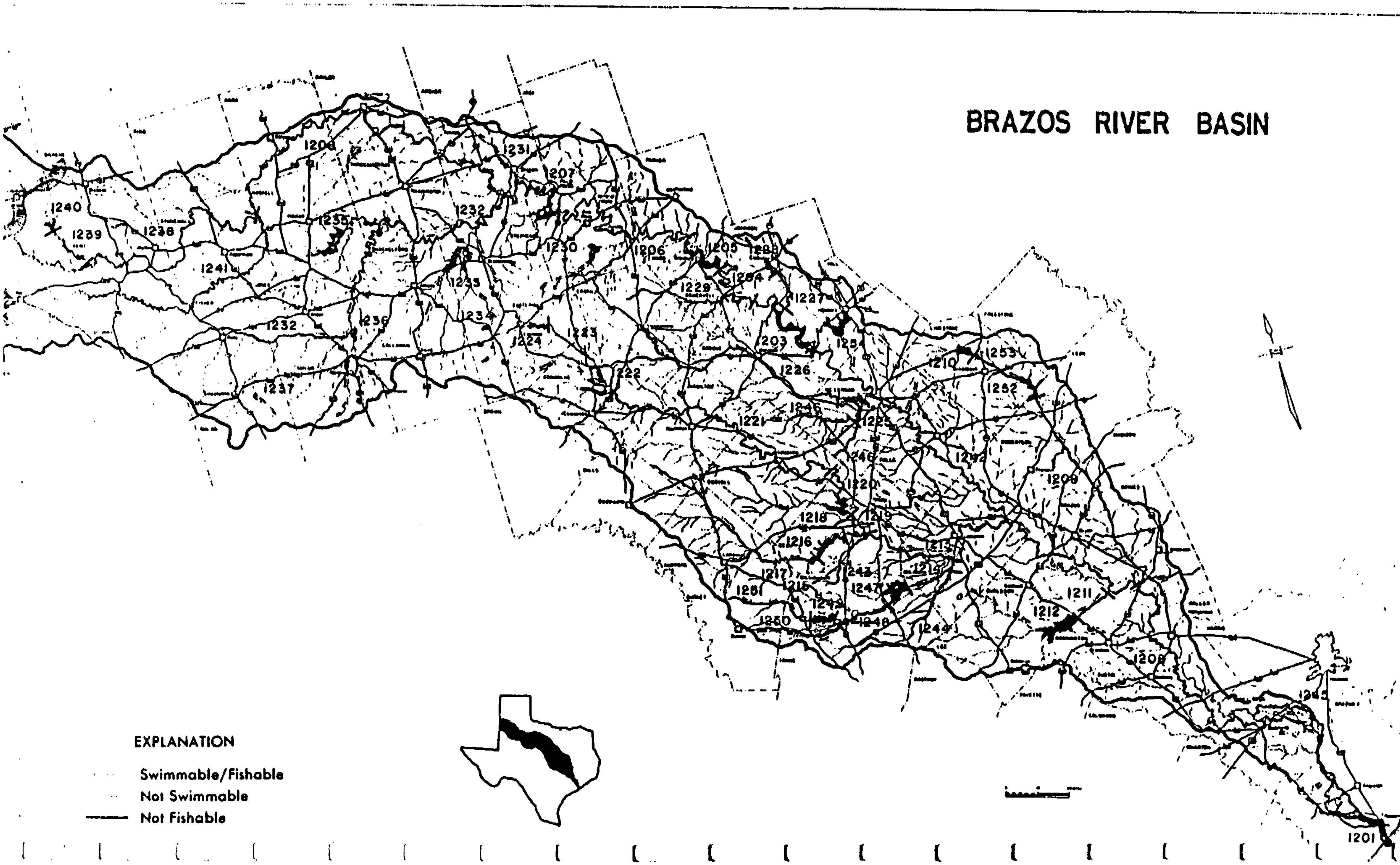
quent Identification Maps for Texas River and Coastal Basins, Texas Water Commission, March 1989, LP-85-01

WATER QUALITY STATUS:

THE FOLLOWING TABLE ILLUSTRATES THE LAST FOUR YEARS (OCT. 1, 1985 THRU SEPT. 30, 1989) OF WATER QUALITY INFORMATION FOR SEGMENT 2425.

PARAMETER	CRITERIA	NUMBER SAMPLES	MINIMUM	MAXIMUM	MEAN	NUMBER OF VALUES OUTSIDE CRITERIA	MEAN VALUES OUTSIDE CRITERIA
DISSOLVED OXYGEN (MG/L)	4.0	52	1.5	17.7	8.4	1	1.5
TEMPERATURE (F)	95.0	56	55.4	89.7	71.4	0	0
PH	6.5-9.0	52	7.4	8.8	8.2	0	0
CHLORIDE (MG/L)	N/A	56	1704	16600	7171	0	0
SULFATE (MG/L)	N/A	47	150	1700	829	0	0
TOTAL DISSOLVED SOLIDS (MG/L)	N/A	40	4585	15725	10271	0	0
FECAL COLIFORMS (#/100 ML)	200	48	5	2700	53	12	833

TOTAL DISSOLVED SOLIDS WERE ESTIMATED BY MULTIPLYING SPECIFIC CONDUCTANCE BY .50


BRAZOS RIVER BASIN
EXPLANATION
Swimmable/Fishable
Not Swimmable
Not Fishable

Appendix C

Lists of Sensitive Environments

Surface Water and Air Pathways
Sensitive Environments

U.S. Environmental Protection Agency Hazard Ranking System criteria for evaluating water and air exposure pathways:

Critical habitat for federally designated endangered or threatened species
Marine sanctuary
National park
Designated federal wilderness area
Ecologically important areas identified under the Coastal Zone Wilderness Act
Sensitive areas identified under the National Estuary Program or Near Coastal Water Program of the Clean Air Act
National monument
National seashore recreation area
National lakeshore recreation area

Habitat known to be used by federally designated or proposed threatened or endangered species
National preserve
National or state wildlife refuge
Unit of coastal barrier resources system
Federal land designated for protection of natural ecosystems
Administratively proposed federal wilderness area
Spawning areas critical for the maintenance of fish/shellfish species within a river system, bay, or estuary
Migratory pathways and feeding areas critical for the maintenance of anadromous fish species in a river system
Terrestrial areas utilized by large or dense aggregations of vertebrate animals (semiaquatic foragers) for breeding
National river reach designated as recreational

Habitat known to be used by state-designated endangered or threatened species
Habitat known to be used by species under review for federally designated endangered or threatened status
Coastal barrier (partially developed
Federally designated scenic or wild river

State lands designed for wildlife or game management
State-designated scenic or wild river
State-designated natural areas
Particular areas, relatively small in size, important to maintenance of unique biotic communities

State-designated areas for the protection/maintenance of aquatic life under the Clean Water Act

Wetlands

Soil Exposure Pathway
Terrestrial Sensitive Environment

U.S. Environmental Protection Agency Hazard Ranking System criteria for evaluating soil exposure pathways:

Terrestrial critical habitat for federally designated endangered or threatened species
National park
Designated federal wilderness area
National monument

Terrestrial habitat known to be used by federally designated or proposed threatened or endangered species
National preserve (terrestrial)
National or state terrestrial wildlife refuge
Federal land designated for protection of natural ecosystems
Administratively proposed federal wilderness area
Terrestrial areas utilized by large or dense aggregations of animals (vertebrate species) for breeding

Terrestrial habitat used by state-designated endangered or threatened species
Terrestrial habitat used by species under review for federally designated endangered or threatened status

State lands designed for wildlife or game management
State-designated natural areas
Particular areas, relatively small in size, important to maintenance of unique biotic communities

Appendix D

Analytical Data from Previous Investigations

Table 1 Mobile Waste Controls Results of TWC Monitoring Well Sampling Program
December 11, 1991

Well ID	COD	TOC	Cl^-	TSS	VSS	TDS	Cyanides	Phenols	NO_2-N	NO_3-N
MW-1	<5	5	132	244	14	814	-	-	-	-
MW-2					Sample not taken.					
MW-5	350	129	782	134	25	2,160	<0.02	23	<0.01	<0.01
MW-6	134	6	58	<5	26	831	<0.02	<5	<0.01	<0.01
MW-8	60	25	*	23	5	1,270				
MW-9	157	57	553	75	15	1,760	<0.02	15	<0.01	<0.01
MW-10	531	192	73	194	62	2,400	<0.02	40	<0.01	<0.01

All measurements in milligrams per liter.

* Copy of analytical data sheet indecipherable.

Table 2
Mobile Waste Controls
Monitoring Well Sampling Results
December 11,1991

December 11,1991	Ag	As	Ba	Cd	Cr	Cu	Hg	Mn	Ni	Pb	Se	Zn	Al	Co	V	Chloride	COD	Cyanide	pH	Phenol	Sulfide	TDS	TOC	VSS	TSS
	ug/L															mg/L		ug/L		ug/L	mg/L				
MW-1	<0.2	<4.0	290	3.6	<5.0	8.8	0.98	77.0	<22.0	5.20	<4.0	44.0	880	<9.0	<8.0	118	60	<10	6.64	<10	<0.16	770	2.2	93	253
MW-2	<0.2	2100	500	1.0	<5.0	<8.0	<0.2	4000	30.0	<0.2	<4.0	14.0	190	<9.0	<8.0	470	180	<10	6.60	211	1.12	1800	49	40	120
MW-5	<0.2	66	1100	0.9	<5.0	<8.0	<0.2	2800	<22.0	<0.2	<4.0	38.0	310	<9.0	11.0	667	320	<10	6.62	310	1.44	2380	105	60	180
MW-6	<0.2	63	840	13.0	26.0	<8.0	<0.2	2400	<22.0	230	<4.0	180,000	690	16.0	57.0	51	60	<10	6.93	21	0.48	790	19	400	1700
MW-7	Not Sampled at this Time																								
MW-8	<0.2	9.7	610	3.0	<5.0	<8.0	<0.2	1500	<22.0	2.8	<4.0	41.0	220	<9.0	<8.0	220	70	<10	6.64	<10	<0.16	1270	19	<10	30
MW-9	<0.2	5.2	240	1.6	<5.0	<8.0	<0.2	570	<22.0	5.5	<4.0	31.0	2600	<9.0	9.4	90	40	<10	7.44	<10	<0.16	500	1.6	<10	260
MW-9D	<0.2	4.4	220	0.9	<5.0	<8.0	<0.2	540	<22.0	2.6	<4.0	23.0	2600	<9.0	9.6	86	40	<10	7.47	<10	<0.16	530	1.3	100	900
MW-10	<0.2	16.0	560	3.8	10.0	51.0	4.0	990	<22.0	7.2	<4.0	110.0	1200	<9.0	10.0	852	560	<10	6.67	404	4.96	2310	211	60	160

TWC1.WK3

Table 3
Mobile Waste Controls
Concentrations of Volatile, Semi-Volatile and Organic Compounds in Water
December 11,1991

	Volatiles								Semi-Volatiles					
December 11,1991	acetone	1,1,2,2 tetrachloroethan	chloroform	benzene	toluene	chlorobenzene	ethylbenzene	xylenes (total)	naphthalene	4-chloroaniline	Bis (2-ethyhexyl) phthalat	benzoic acid	2-methinaphthalene	N-Nitrosodiphenylamin
	ug/L								ug/L					
MW-1	14	3*	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW-2	11	ND	ND	7	ND	19	ND	ND	2*	140	6*	ND	ND	ND
MW-5	29	ND	6	11	9	16	32	18	17	83	4*	ND	ND	ND
MW-5D	NA	NA	NA	12	9	16	34	18	ND	ND	ND	ND	ND	ND
MW-6	20	ND	ND	ND	ND	6	ND	ND	ND	ND	10*	19*	ND	ND
MW-7	Not Sampled at this Time													
MW-8	10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW-9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3*	ND	ND	ND
MW-9D	6*	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW-10	11	ND	ND	14	ND	26	95	26	13*	550**	13*	ND	9*	22

NA - Not Available
ND - Not Detected
* - Below listed detection limit
** - Compound amount taken from a 1:10 dilution

	Organics				
December 11,1991	2,4,5 TP (Silvex)	Dalapon	Dicamba	Dichloroprop	Dinoseb
	ug/L				
MW-10	0.16*	16	1.4	3.3	1.4

* - Below method detection limit

Table 4 Mobile Waste Controls Results of TWC Sampling Program
February 20, 1992

Sample ID	City of Houston Sample ID	Location	Results (mg/L) COD	TOC	Cl^-
Westwind Lake					
WEST #1	790	Mid-lake; east side of island	<5	7	21
WEST #2	788/789	East bank near MW-2	<5	5	21
Bass Lake					
BASS #1	792	East corner along bank near MW-9	<5	3	19
BASS #2	791	Mid lake; north side island	<5	3	19
Windmill Lake					
WIND #1	794	North of pier	<5	5	13
WIND #2	793	North side of island; mid-lake	<5	4	13
4th Lake	795	South bank of 4th lake	16	7	14

Table 5 Mobile Waste Controls Results of City of Houston Lake and Sediment Sampling February 20, 1992

Sample ID	Sample Matrix	Volatile Priority Pollutants Detection Limit 10 ppb	Semivolatile Priority Pollutants Detection Limit 10 ppb	Fecal Coliform
788	Water	ND	ND	<200
789	Water	ND	ND*	400
790	Water	ND	ND	<200
791	Water	ND	ND	NA
792	Water	ND	ND	NA
793	Water	ND	ND	NA
794	Water	ND	ND	NA
795	Water	ND	ND	NA

ND = not detected

NA = not available

* Detection limit 20 ppb.

Table 6 Mobile Waste Controls
Results of City of Houston Lake Sampling
February 20, 1992

Sample ID	Ag	As	Ba	Cd	Cr	Cu	Hg	Mn	Ni	Pb	Zn	Se
788	<0.01	<0.001	<0.1	<0.01	<0.01	<0.01	<0.001	<0.01	<0.03	<0.04	<0.01	<0.002
790	<0.01	<0.001	<0.1	<0.01	<0.01	<0.01	<0.001	<0.01	<0.03	<0.04	<0.01	<0.002
791	<0.01	0.003	<0.1	<0.01	<0.01	0.05	<0.001	<0.01	<0.03	<0.04	<0.01	<0.002
792	<0.01	<0.001	<0.1	<0.01	<0.01	<0.01	<0.001	<0.01	<0.03	<0.04	<0.01	<0.002
793	<0.01	<0.001	0.27	<0.01	<0.01	<0.01	<0.001	<0.01	<0.03	<0.04	<0.01	<0.002
794	<0.01	<0.001	0.54	<0.01	<0.01	<0.01	<0.001	<0.01	<0.03	<0.04	<0.01	<0.002
795	<0.01	<0.001	<0.1	<0.01	<0.01	<0.01	<0.001	<0.01	<0.03	<0.04	<0.01	<0.002

All measurements in milligrams per liter.

Table 7
Mobile Waste Controls
Concentrations of Metals in Water Matrix
February 20, 1992

February 20, 1992	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Mg	Mn	Na	Ni	Pb	Sb	Se	Tl	V	Zn	Fecal Coliform
	ug/L																							Colonies/100 ml
Bass-2	<2.0	270	<2.0	62	<1.0	13,719	<3.0	<4.0	<3.0	5.3	149	<0.2	2,128	2,781	5.7	49,385	<22.0	<1.0	<30.0	<2.0	3.2	44.0	10.0	401
Wind-1	<2.0	84.0	<2.0	67.0	<1.0	18,146	<3.0	<4.0	<3.0	<3.0	99.0	<0.2	2,314	4,295	6.6	22,650	<22.0	<1.0	<30.0	<2.0	<2.0	<4.0	16.0	<1
West-1	<2.0	82.0	<2.0	85.0	<1.0	18,090	<3.0	<4.0	<3.0	3.3	95.0	<0.2	2,903	8,526	6.2	23,890	<22.0	<1.0	<30.0	<2.0	<2.0	<4.0	13.0	<1
West-2	<2.0	112	3.0	91.0	<1.0	29,693	<3.0	<4.0	<3.0	3.9	118	<0.2	3,037	8,822	7.0	25,071	<22.0	<1.0	<30.0	<2.0	<2.0	<4.0	17.0	27
Bass-1	<2.0	302	3.0	65.0	<1.0	13,824	<3.0	<4.0	<3.0	6.3	168	<0.2	1,611	2,889	3.3	51,889	<22.0	<1.0	<30.0	<2.0	<2.0	<4.0	19.0	<1
Wind-2	<2.0	85.0	5.4	71.0	<1.0	18,386	<3.0	<4.0	<3.0	<3.0	82.0	<0.2	1,818	4,276	4.4	22,867	<22.0	<1.0	<30.0	<2.0	<2.0	<4.0	19.0	<1
4th Lake	<2.0	178	5.0	106	<1.0	33,867	<3.0	<4.0	<3.0	5.8	531	<0.2	2,531	8,002	224	26,985	<22.0	5.7	<30.0	3.0	<2.0	44.0	47.0	<1

Concentrations of Metals in Sediment and Soil Matrix

February 20, 1992	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Mg	Mn	Na	Ni	Pb	Sb	Se	Tl	V	Zn	Matrix
	mg/Kg																							
Bass-2	<1.9	19,576	13.0	149	<0.93	3,902	<280	7.1	17.0	58.0	15,447	<0.47	1,642	2,463	90.0	591	<20.0	26.0	<28.0	<1.9	7.2	32.0	59.0	Sediment
Wind-1	<0.62	1,589	3.3	18.0	<0.31	632	0.93	1.9	2.3	4.3	2,034	<0.16	173	257	12.0	48.0	<6.8	4.3	<4.5	<0.62	0.82	5.8	13.0	Sediment
West-1	<0.78	8,573	9.7	72.0	<0.39	9,753	<1.2	4.3	9.3	19.0	9,216	<0.19	1,265	1,852	237	139	8.9	18.0	<12.0	<0.77	<0.77	18.0	53.0	Sediment
West-2	<1.3	26,829	17.0	128	<0.67	21,131	<2.0	10.0	26.0	37.0	19,749	<0.34	4,151	5,713	272	270	24.0	32.0	<20.0	<1.3	<1.3	41.0	122	Sediment
Bass-1	<0.62	5,817	5.1	43.0	<0.31	101	<0.92	4.6	5.5	4.0	5,678	<0.15	541	819	56.0	147	<6.8	6.3	<9.2	<0.62	<0.62	14.0	12.0	Sediment
Wind-2	<1.2	11,159	6.8	128	0.94	3,173	<1.8	7.1	12.0	9.7	11,050	<0.3	1,235	1,972	128	195	144	20.0	<18.0	<0.59	<1.2	24.0	41.0	Sediment
4th Lake	<0.58	14,551	5.9	103	<0.29	1,812	<0.87	4.9	14.0	7.0	14,858	<0.15	1,180	1,859	32.0	299	11.0	9.3	<8.7	<0.58	<0.58	28.0	18.0	Sediment
SS-1	<0.55	12,581	6.2	407	<0.27	30,838	0.83	15.0	18.0	18.0	24,857	<0.14	2,238	4,280	327	468	18.0	15.0	<8.3	<0.55	<0.55	56.0	38.0	Soil

Table 8
Mobile Waste Controls
Concentrations of Volatile Organic Compounds in Water, Sediment and Soil Matrices
February 20, 1992

MATRIX	WATER	SEDIMENT AND SOIL									
February 20, 1992	acetone	methylene chloride	acetone	2-butanone	bis (2-ethylhexyl) phthalate	1,1-Dichloroethene	trichloroethene	benzene	toluene	chlorobenzene
	ug/L	mg/Kg			ug/Kg					
Bass-2 (1)	8*	45	160	35*	ND	ND	ND	ND	ND	ND
Bass-2 (2)	ND	59	250	50	190	ND	ND	ND	ND	ND
Wind-1 (1)	6	18	33	ND	ND	ND	ND	ND	ND	ND
Wind-1 (2)	ND	28	61	ND	ND	ND	ND	ND	ND	ND
West-1	6*	ND	ND	ND	ND	ND	ND	ND	ND	ND
West-2 (1)	4*	17*	99	ND	ND	ND	ND	ND	ND	ND
West-2 (2)	ND	47	220	34	ND	ND	ND	ND	ND	ND
Bass-1 (1)	5*	NA	21	ND	ND	ND	ND	ND	ND	ND
Bass-1 (2)	ND	ND	80	ND	ND	ND	ND	ND	ND	ND
Wind-2	4*	ND	ND	ND	ND	ND	ND	ND	ND	ND
4th Lake (1)	9*	9	ND	ND	ND	ND	ND	ND	ND	ND
4th Lake (2)	ND	19	ND	ND	ND	ND	ND	ND	ND	ND
4th Lake-MS (1)	ND	27	ND	ND	ND	98	83	90	82	91

MATRIX	WATER								
February 20, 1992	acetone	methylene chloride	2-butanone	bis (2-ethylhexyl) phthalate	1,1-Dichloroethene	trichloroethene	benzene	toluene	chlorobenzene
	ug/L								
4th Lake-MS (2)	4*	ND	ND	ND	53	44	53	47	46

ND - Not Detected
* - Below listed detection limit
(1) Initial sampling analytical results
(2) re-analysis of same sample; dilution factors may change.
MS - Matrix spike

TWC4.WK3

Table 9
Mobile Waste Controls
Concentrations of Semi–Volatile Organic Compounds in Water Matrix
February 20, 1992

MATRIX	WATER											
February 20, 1992	isophorone	phenol	2–chlorophenol	1,4–dichlorobenzene	N–Nitrosodipropylamine	1,2,4–trichlorobenzene	P–Chloro–M–Cresol	Acenaphthene	4–nitrophenol	2,4–dinitrotoluene	pentachlorophenol	Pyrene
	ug/L											
4th Lake (MS)	ND	98	120	73	64	73	130	71	180	91	120	110
4th Lake (MSD)	ND	94	150	140	110	170	230	160	160	210	160	210

Mobile Waste Controls
Concentrations of Semi–Volatile Organic Compounds in Sediment and Soil Matrix

MATRIX	SEDIMENT AND SOIL											
February 20, 1992	isophorone	phenol	2–chlorophenol	1,4–dichlorobenzene	N–Nitrosodipropylamine	1,2,4–trichlorobenzene	P–Chloro–M–Cresol	Acenaphthene	4–nitrophenol	2,4–dinitrotoluene	pentachlorophenol	Pyrene
	ug/Kg											
West–1	100*	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4th Lake (MS)	ND	1,700	2,100	1,100	400*	1,200	2,200	1,200	1,900*	1,500	ND	1,500
4th Lake (MSD)	ND	1,800	2,200	1,200	440	1,300	2,500	1,300	2,400	1,800	250*	1,900

ND – Not Detected
* – Below listed detection limit
** – Re–analysis of seim–volatile compounds not summarized on this table
MS – Matrix spike
MSD – Matrix spike duplicate

TWCS.WK3